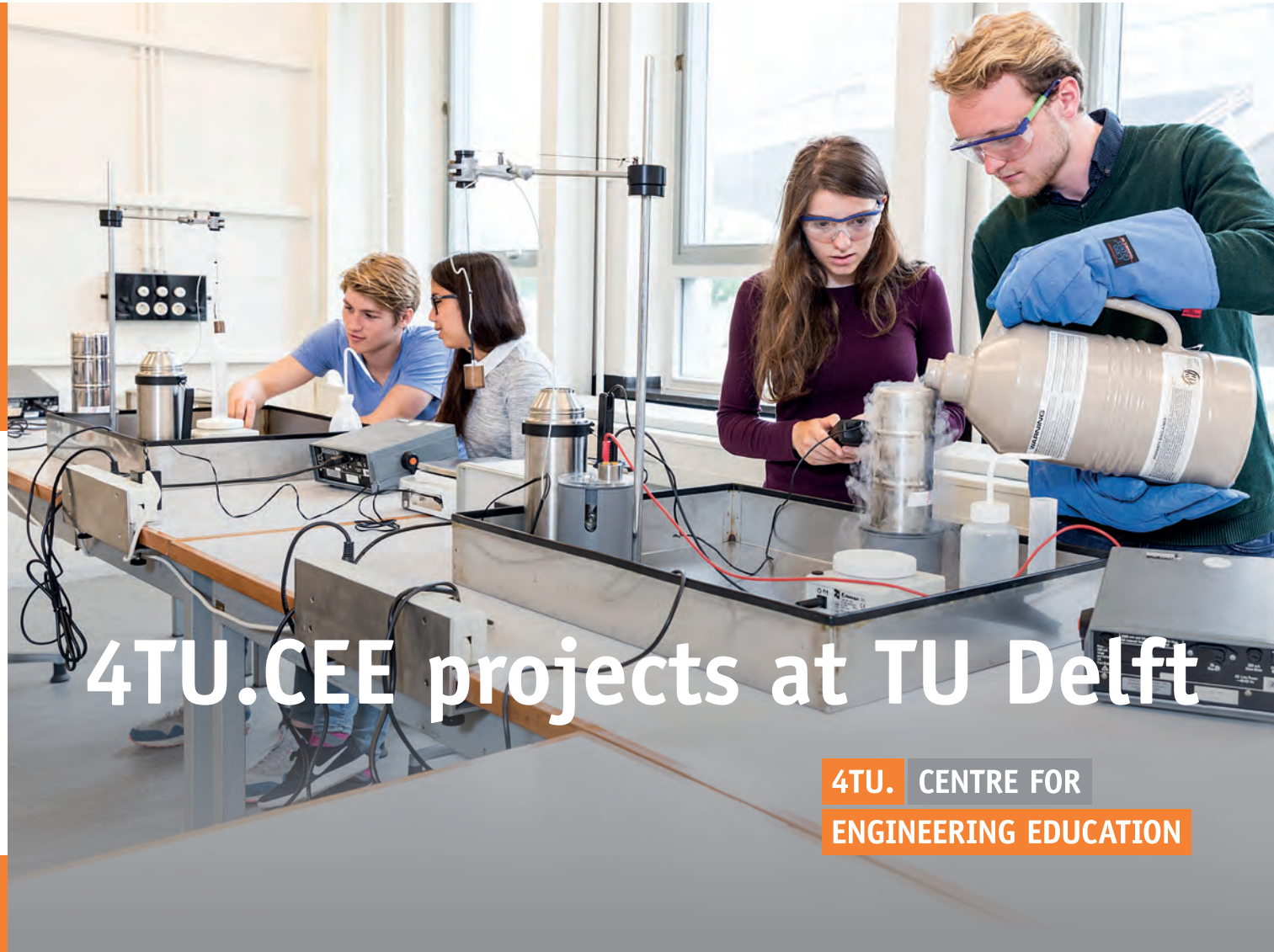

4TU.CEE projects at TU Delft

4TU. CENTRE FOR ENGINEERING EDUCATION

TU Delft Delft University of Technology

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

UNIVERSITY OF TWENTE.

WAGENINGEN UNIVERSITY & RESEARCH

4TU.

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Preface

4TU.CEE at TU Delft 2020 and beyond

With great pleasure we present to you the 4TU.CEE TU Delft project portfolio. It shows the variety of themes and topics that the Delft pillar of the 4TU.Centre for Engineering Education has addressed over the last years. It also presents the most important project results and progress for both educational innovation and education research projects. We are happy to see that colleagues from a variety of faculties have found their way to us to jointly improve engineering education at TU Delft.

The year 2020 has been a special one for 4TU.CEE Delft as Aldert Kamp retired as leader and a new management team has been installed. As a new team we would like to further strengthen the links with the TU Delft community. We want to support teachers interested in innovating and/or doing research into their education on topics such as interdisciplinarity, entrepreneurial learning, innovative learning spaces and more. We will continue to work closely with our 4TU.CEE colleagues in Wageningen, Eindhoven and Enschede to jointly research and innovate our engineering education for tomorrow's engineer.

Do not hesitate to contact us if you would like to connect with colleagues with similar education interests, want to receive regular updates on funding opportunities, or if you want to get access to handy tools, valuable research or promising practices. Visit our 4TU.CEE website and feel invited to contact us personally!

About us

Marcus is professor for *Digital Education* and also leads the Leiden-Delft-Erasmus Centre for Education and Learning (LDE-CEL). Remon is associate professor *Spatial Planning & Strategy*, and leads the *Research-on-Education-Innovation* programme at the faculty of Architecture & the Built Environment. Renate has been the programme coordinator for 4TU.CEE since 2014 and is educational researcher at TU Delft. She also participates in the taskforce teaching and learning of CESAER (European association

of universities of science and technology). We will be working closely as a team to achieve 4TU. CEE's ambitions for the coming years:

- Help faculties to further improve our Delft engineering education. We will have to cope with accelerating technological and societal changes, and constantly make our engineering programmes up-to-date and future proof at the same time. This kind of *agile engineering education* will not only impact (required) teaching and leadership staff competencies, but also course and curriculum (re) design: both contents and pedagogies.

- Inspire staff to develop their teaching competencies, and encourage faculties in advancing careers via education: teaching excellence, educational leadership and research-on-education. As development in educational excellence is pivotal for the success of the future of our TUs. We will support 'educators as innovators' to embed educational innovation in the core curriculums and combine evidence based research with high quality teaching, and learning.

Marcus Specht, Remon Rooij, Renate Klaassen
4TU.CEE TU Delft management team
Delft, November 2020

Introduction

Vitalising Knowledge for Engineering Education: 'Innovating engineering education for tomorrow's engineer'

4TU.CEE is a virtual network organisation that aims to jointly inspire, stimulate, support and disseminate effective and high quality engineering education through research and the application of evidence-based innovations within the engineering education domain. 4TU.CEE is the place for teachers and scientists with questions and ambitions in the domain of engineering education.

In Delft we have worked with a programme format in which there are four main goals:
- improving the evidence based knowledge for engineering education;
- working more future proof with innovative teaching methods;
- sharing and building a knowledge base across faculties/institutions;
- expanding our knowledge network via international collaborations.

The impact and contribution of our activities are found in outcomes such as published articles, books or conference contributions, participation in events, students receiving more innovative education, and the realisation of support materials for engineering education.

Themes

In the last years the Delft pillar of 4TU.CEE focused on the themes of:
- engineering roles
- interdisciplinarity
- maker spaces
- student learning
- evidence based teaching & learning
- computational thinking
- teaching excellence.

These themes have been derived from the strategic development plan of 4TU.CEE 2017 -2021, and were calibrated with the Executive Board of TU Delft and the 4TU-Board.

This project portfolio booklet presents the 4TU.CEE projects that were or are executed in Delft under the umbrella of these themes. You will find a brief introduction to each theme and a number of projects delivered over the past years, or projects that are still ongoing. Additionally, the projects are assessed on their impact and feasibility.

Fig. 1 Projects in percentages per theme

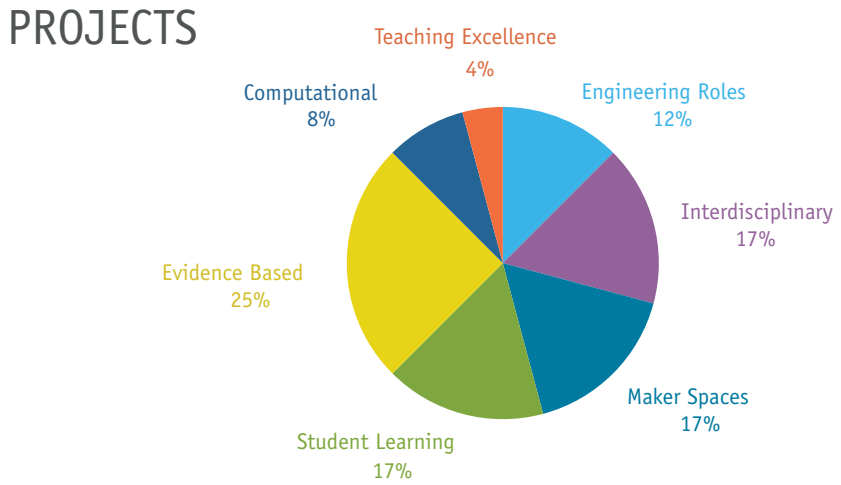


Figure 1 presents the distribution of projects over the themes in percentages. The most dominant theme is 'evidenced based teaching and learning', due to the large contribution by the faculties of Architecture & the Built Environment and Industrial Design Engineering with projects in the area of design education. Equally, a number of projects of the faculty of Technology, Policy and Management are found in the area of ethics. The theme of 'student learning' has a heavy focus on research and innovation in math education at the faculty of

Electrical Engineering, Mathematics, and Computer Sciences. The themes of 'engineering roles', 'interdisciplinarity' and 'maker spaces' are more generic in nature, with projects across TU Delft faculties, and the latter two are cross institutional. 'Computational thinking' so far has focused on quantum technology. 'Teaching excellence' pertains to the Teaching Culture Survey which was held at all 4TU institutions and was administered in Delft.

The outcomes have been thoroughly analysed, reported and presented by dr. Ruth Graham for 4TU.CEE. The results have been distributed within the institutions and were discussed at TU Delft intensively.

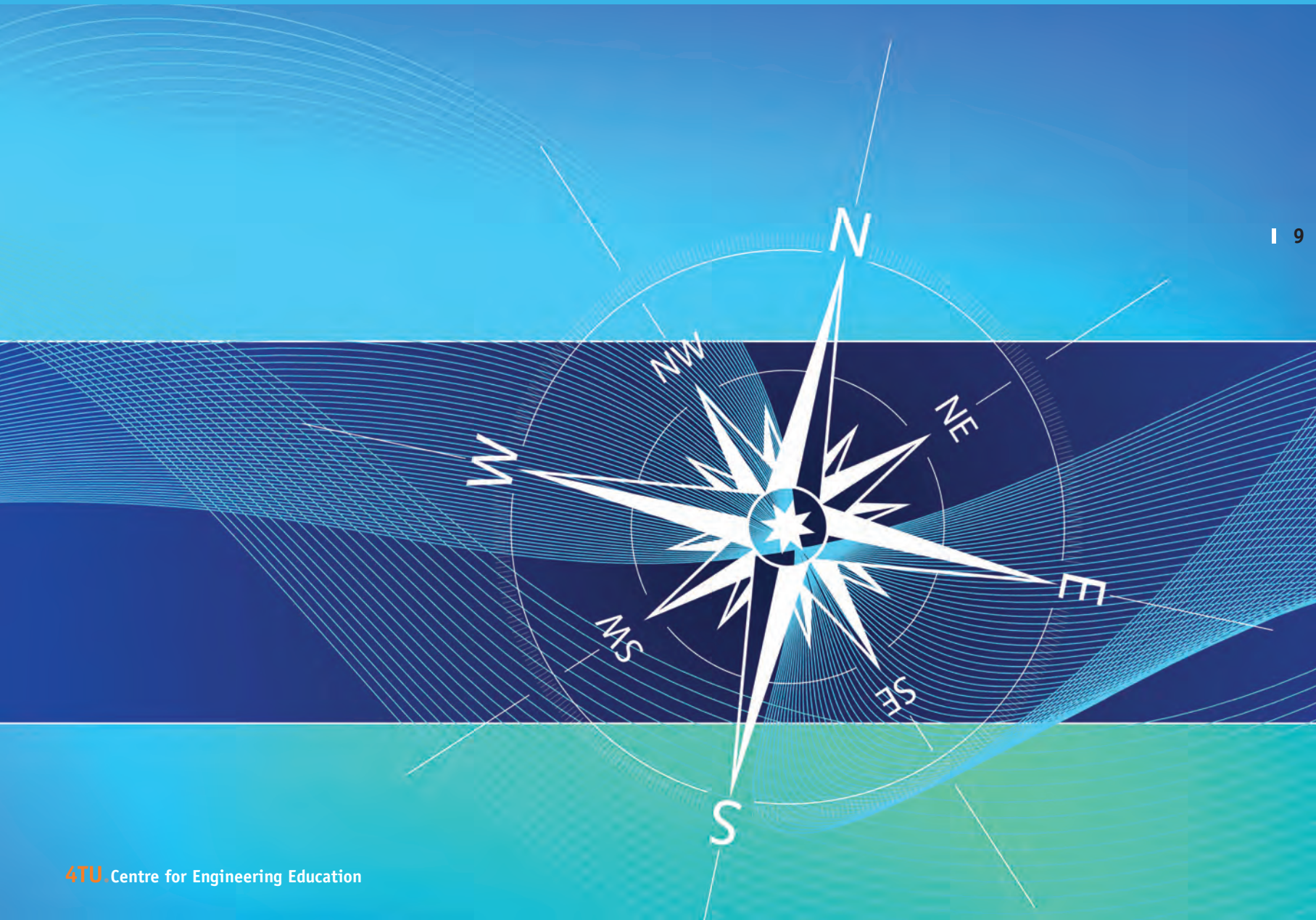
Internally, the teaching excellence activities are run by HR, Education & Student Affairs (ESA) and Strategic Development. Therefore, this theme is not presented in this booklet. Most of the projects mentioned in this booklet are still ongoing. For the latest project update check out the 4TU.CEE Innovation map or contact us personally. On the contact page you will find our details and focus areas.

Renate Klaassen
Programme Coordinator (since 2014)

Theme

Engineering Roles

» This theme is about educating future engineers with different engineering profiles and the development of the professional identity of engineers. This may range from technical orientation to more entrepreneurial or societal orientation. These skills are needed to develop future proof engineers, who are able to contribute to the sustainable development goals. It also deals with the new skills and competencies that future engineers need, such as digital literacy skills, boundary crossing skills, entrepreneurial skills and creative and critical thinking. Finally, the consequences of these new profiles and skills for the curriculum of engineering programmes are important: what teaching strategies work best? How can skills be best integrated and assessed and also be a part of learning lines? Projects undertaken under this theme focus on future engineering roles at TU Delft.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Navigating the Landscape of Higher Engineering Education

Coping with decades of accelerating change ahead

About the project

The 2016 report 'Engineering Education in a Rapidly Changing World' portrayed the VUCA (Volatile, Uncertain, Complex, Ambiguous) world and a personal vision on the changes that are needed for future-fit higher engineering education. The report stirred considerable debate across and beyond TU Delft and is being used by many universities as an inspiration for educational leaders and teaching staff to rethink their courses and programmes.

This new report aims to complement that vision with new insights and offers a forward-thinking perspective on higher engineering education. The ideas and examples in the report are multi-sourced and leveraged with a personal touch. It discusses the greater responsibility students have for their own education and learning process, the importance of professional skills, and the integration of the digital transformation and responsible engineering in curricula.

Last but not least it looks at the essence of impactful education, the need to upskill staff, and the impact of the vastly altered population of learners, mainly Generation-Z students.

Objective

Bridge the gap between visionaries, thought leaders and academic teaching staff on the shop floor.

Outcomes or Deliverables

Descriptions of frameworks, concrete examples and guiding principles for relevant subjects, such as the changing roles in the engineering profession, the shift in focus from teaching to learning, learning as inquiry, diversity in the classroom as well as in the educational portfolio, the learning, unlearning and relearning of staff competencies, the strengthening of university-industry collaboration, and empowering leadership.

Lessons learned

The concluding chapter has been written as a compass for educational leaders. It has four compass points: Skillsets and mindsets for 21st century engineers; Pedagogical and technological innovations in education; Continuous/life time education: continuous upskilling and relearning; and Educational strategy and leadership. In these compass points it gives 24 recommendations for the development of educational vision and strategy and their implementation in organisations and curricula.

Duration of the project

This project has been completed.

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Download the booklet

The University of Tomorrow

Future roles of engineers

About the project

The project 'University of Tomorrow' addresses the need for the future university to adapt its approach to education. In a collaborative effort between Reframing Studio and 4TU.CEE TU Delft a concept for the future university and the future roles of engineers in and beyond education is designed and tested in real life contexts.

The University of Tomorrow is a continuation of the Free spirits Think Tank project. Like in the Think Tank, the 'Personology Arena' is an elaboration of Engineering Roles. The learner is no longer an engineer, but rather a technee – a lifelong learner, with a purpose driven mission, in which the engineering roles are a guiding principle to realise the purpose and contribution to society.

Characteristic of the 'University of Tomorrow' is the notion of agency or entrepreneurial mindset, challenge focused, cross border collaboration both across disciplines and beyond the university walls in networked groups, contextualised knowledge gathering and 360 degree feedback.

Objective

The objective is to offer a new format of flexible learning, preparing people to the future developments and complex challenges during their life.

Outcomes or Deliverables

The outcomes are fluid, however, main results are 1) a conceptual model of the future university and 2) engineering roles for the future technee that will help educational management and educational designers to create their own education according to the proposed body of thought.

Outcomes

- Three validation workshops at TU Delft, one at the Dutch Design week and workshops with students (all in 2017)
- A design-based vision on future roles in engineering (CDIO 2018)
- Booklet: Engineer of the Future; envisioning Higher Engineering Education in 2035 (2019) ISBN: 978-94-6366-258-1
- Reframing website
- Flyer: Designing Engineering Education for the Future
- Presentation at WUR Education Day 2019

Lessons learned

The University of Tomorrow has flexible learning paths, challenge/phenomenal based education in (inter)disciplinary teams, pays attention to personal development and has a strong relation with the world beyond the university that relate to the 3 major engineering dimensions that will define the future:

- engaging with the making of artefacts in the technology domain for societal or phenomenal purposes
- collaborating on an interpersonal or systems level
- adapting to the life cycle and innovation of product, systems, services, strategic development

Duration of the project

2017 and ongoing.

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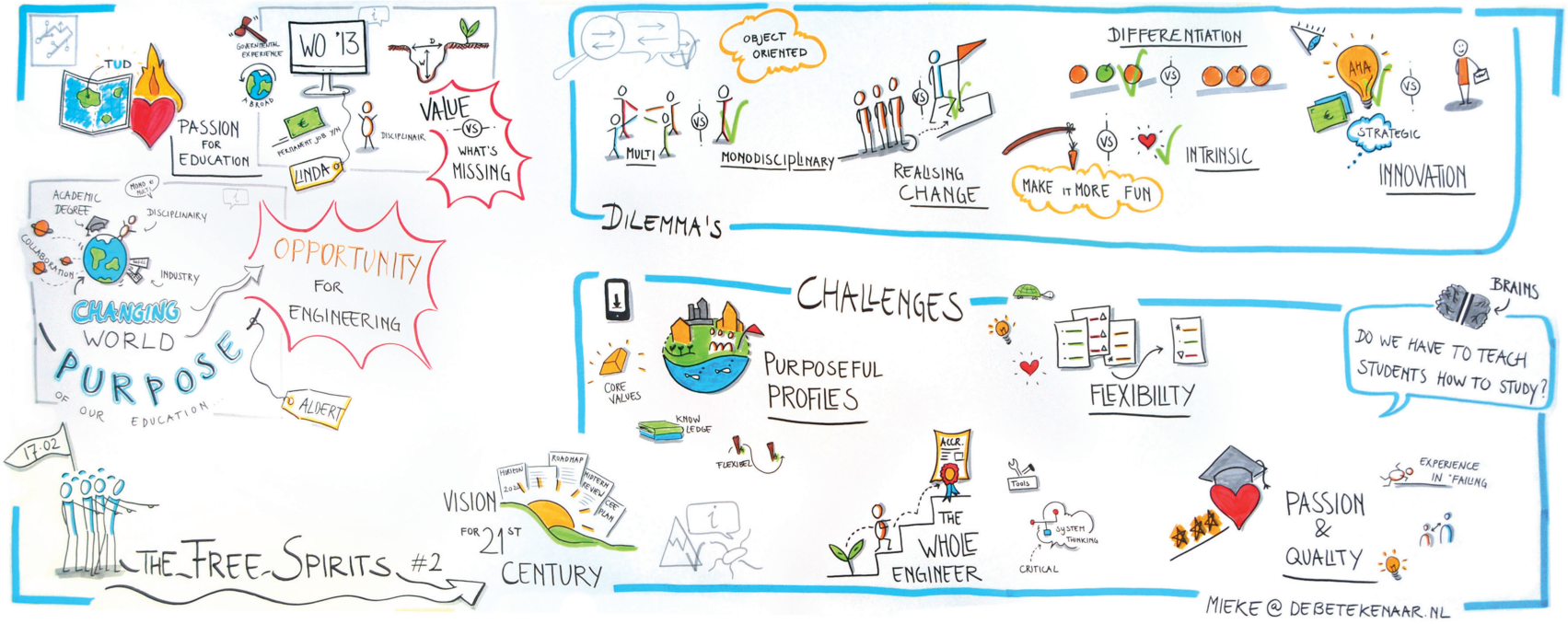
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PASSION FOR EDUCATION
VALUE VS WHAT'S MISSING
LINDA
ACADEMIC DEGREE
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PURPOSE OF OUR EDUCATION
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THE FREE SPIRITS #2
VISION FOR 21ST CENTURY
ROADMAP
OBJECT ORIENTED
MULTI
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REALISING CHANGE
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AHA
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INNOVATION
DILEMMA'S
CHALLENGES
CORE VALUES
KNOWLEDGE
PURPOSEFUL PROFILES
FLEXIBILITY
BRAINS
DO WE HAVE TO TEACH STUDENTS HOW TO STUDY?
ACCR.
THE WHOLE ENGINEER
SYSTEM THINKING
CRITICAL
EXPERIENCE IN FAILING
PASSION & QUALITY
MIEKE @ DEBETEKENAAR.NL

Validating Engineering Roles

Designed in the Think Tank 'Free Spirits' TU Delft

About the project

During the years 2017-2019, nine workshops have been held to validate the 'Engineering Roles'. These roles were drawn up in the TU Delft Think Tank 'Free Spirits' to contribute to realising new ways of educating future engineers.

These workshops were held in collaboration with the faculties of ABE, CEG and TPM, TU Delft Deltas, Infrastructures and Mobility Initiatives (DIMI), the department Science Education and Communication, the master Robotics and IGEM. The workshops focused on embedding the engineering roles as tools for (interdisciplinary or disciplinary) design assignments. These were embedded in the initial or evaluative design phase of a project.

Objective

The goals of these workshops were primarily to contribute to evaluating the relevance and applicability of engineering roles in the engineering curriculum and to establish the added value for design assignment in a particular field. They also served to develop a validated questionnaire on the engineering roles of the participants and their identification with engineering roles as tool for personal growth and teambuilding.

Outcomes & Deliverables

Included here some of the main results:

- Tools of the Engineering Roles were used in an explorative workshop in a project towards safe, sustainable delta's and metropoles and resilient and durable infrastructures in the DIMI initiative. The results of the project and the Engineering Roles have been documented in the book: Intelligent SUBsurface Quality (2016).
- Three workshop were held by the Building with Nature initiative as part of a research programme on coastal flood risk reduction (in 2016, 2017, 2018).
  Contribution to series 'Research in Urbanism' in Volume 7, chapter 4: 'Building with Nature perspectives – cross disciplinary BwN approaches of coastal regions'.
- Workshop by IGEM -2017 team to evaluate the team process, identify engineering roles and improve the product outcomes.
- Presentation at Education day TU Delft in 2017.
- SEFI-Poster Presentation (2018). Impact of Engineering Roles in a design process for solving complex problems.
- Design your next career move, currently being upgraded (online MOOC).

Lessons learned

- Engineering roles can be used for a better balance in divergent views at the beginning of design projects.
- In evaluative situations the roles can be used to identify missing roles in terms of team work and missing content as a result of looking through a roles perspective towards a problem.
- Engineering roles enhance interdisciplinary integration.
- A wide variety of people were able to identify with their role and considered it beneficial to know their preference, yet pleaded not to be pigeonholed by it.

Duration of the project

2017-2019.

Contact details

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- Jill Slinger/Baukje Kothuis (TPM/ Civil Engineering/NSF-Pire)
- Maarten van der Sanden/Caroline Wehrman (SEC)
- Joanna Daudt/Chris Verhoeven (EWI – Robotics)
- Peter Hamersma (MST)
- Bertien Broekhans (at the time TPM)
- Margaret Welten/Claire Visee (Career Centre)
- Daniëlle Ceulemans (4TU.CEE)
- Renate Klaassen
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Theme

Inter-disciplinarity

» Engineering Education is becoming more interdisciplinary by nature. How can interdisciplinarity be best organised in learning activities, curricula or assessment? What types of interdisciplinarity exist and how different are they: what makes integrating different engineering domains and integrating them with social sciences work? How can students and teachers learn to collaborate in an interdisciplinary team? What role do ethnicity and culture play in (interdisciplinary) collaboration? How can different other actors from society be engaged in interdisciplinary engineering projects?

Projects (to be) undertaken under this theme in Delft are reviewing and researching interdisciplinary and transdisciplinary engineering education and practices and initiating innovative engineering education.

Joint Interdisciplinary Project

A 2nd year master course in a semi-professional environment

About the project

In the Joint Interdisciplinary Project (JIP) 2nd year master students work in a professional and interdisciplinary environment during a 10 week period. In interdisciplinary teams they solve a technological/innovation challenge provided by a company or a semi-governmental organisation, such as WeP, Huskey, Airbus or Reinier de Graaff hospital. The projects demand a good engineering innovation working knowledge in addition to a solid grounding in interdisciplinary and systems thinking.

It also asks for an innovation mindset and entrepreneurial behaviour. The students are guided during the process by a company and academic coach. The project started in 2018 with 14 students and was prolonged in 2019 with 48 students. In 2020 ± 150 students will have the opportunity to take part in the Joint Interdisciplinary Project.

Objective

The aim of JIP is to prepare 2nd year master students for contributing to solving impactful technological challenges, working in interdisciplinary teams in a professional environment.

Outcomes or Deliverables

TU Delft has the ambition to make interdisciplinary education related to external stakeholders widely available to its master students. It wants to prepare students to contribute to solving societal challenges by providing them with a solid grounding in interdisciplinary skills, sustainability and entrepreneurial thinking. To this end TU Delft will increase the elective space in MSc programmes with Multi- or Interdisciplinary teamwork as an option for the MSc thesis within the Faculty or interfaculty and 'Personalised learning paths – freedom of choice' (TU Delft Strategic Framework 2018-2024).

JIP has been growing steadily over the years and is expected to attract more students and companies to become involved in the years to come.

Extensive information is available on

- the JIP website
- the 4TU.CEE innovation map
- the weblog Aldert Kamp
- the TU Delta
- CDIO2020 paper

Lessons learned

Organisation

- Coordination is necessary to bridge the gap between industry and the academic world. Active involvement in team coaching is needed in the early stages of the project to make the outcome a success.
- Access to company coaches and professionals allow for additional education of students (R&D, Business lines, CTO-role models provide rich and professional resources in kind).
- Working spaces on campus are needed for the student teams.
- JIP requires year around preparation with a dedicated team.

Students learned to

- Calibrate expectations and needs of companies, academic rigor and their own 'team' desires for innovative and sustainable results and to stand up for their choices.

- Prepare themselves better in presenting, consulting and interacting with different stakeholders.
- Identify their strengths and weaknesses in interdisciplinary teamwork.
- Define a problem with a realistic scope for the timespan available.

Duration of the project

2018 and ongoing. From September 2020 this project is embedded at 3mE and will be entirely run by TU Delft.

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Photo: Delphine Chevalier

Routes to Urban Issues

City Deal Kennis Maken: Defining urban issues for education in rich learning environments between students, course coordinators, and municipalities

About the project

Universities and municipalities meet around urban challenges and work collaboratively in the city to create rich learning environments for students, course coordinators, and municipalities. Through these collaborations between city and university, (coordinating) lecturers have faster access to authentic issues in their education, municipalities gain access to the university's knowledge network, and students learn to work on real and concrete issues that intrinsically motivate them.

Nevertheless, urban issues are not directly applicable in an educational context. Because of their complexity, multidisciplinarity or political sensitivity, the issues are sometimes difficult to grasp. It is difficult for the stakeholders involved to deal with the uncertainty in urban issues at the start of an educational cooperation.

This project searches for a way to provide guidelines in this process from three perspectives: the student, the course coordinator, and the municipality. The process of designing and delineating urban issues will be analysed in different educational forms within two cooperation programmes of Delft University of Technology, with the Municipality of Delft and AMS Institute.

Objective

The goal is to build a roadmap, based on various practical experiences from these two collaborations, to give stakeholders insight and guidance in defining urban issues suitable for education.

Outcomes or Deliverables

- Complexity analysis of urban issues used in TU Delft education in Delft and Amsterdam
- Journey maps of processes to shape and negotiate urban issues in TU Delft education in Delft and Amsterdam
- Roadmap to serve as tool for students, course coordinators, and municipalities to offer guidance at the start of an educational collaboration
- Workshop on Living Lab Summit 2021 at AMS Institute

Lessons learned

The kick-off of the research project is August 2020. As soon as there are lessons learned, we will be sharing them with the 4TU.CEE community. The City Deal Kennis Maken is performed as a part of the 4TU.CEE PhD-project 'Learning from Science and the City'.

Duration of the project

2020-2023.

Contact details

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Photo: Delphine Chevalier

Learning from Science and the City

How universities and cities are creating new spaces for students to learn

About the project

Universities in the 21st century are under pressure to develop transdisciplinary education allowing students to engage with real-life challenges in society. Transdisciplinarity in higher education is a method of societal valorisation and helps students grow to become professionals equipped with knowledge, skills and attitudes to deal with the complex challenges.

Universities are increasingly engaging in structural collaborations with cities in order to create meaningful learning environments for transdisciplinary higher education through living labs. Yet, we know little about how urban learning ecologies are constructed and the way transdisciplinary competences are developed within them. In order to get more grip on this matter PhD research is currently being conducted. The research zooms in on the Living Lab course within MSc MADE, a joint degree master programme that is hosted at AMS Institute in Amsterdam.

Objective

The research aims to 1) gain a deeper understanding of the learning processes of students in the context of urban learning ecologies and 2) develop new tools to support the development of transdisciplinary competences in that context.

Outcomes or Deliverables

One of the studies within this PhD research is part of the City Deal Kennis Maken project 'Routes to urban challenges' that aims to develop a roadmap for students, course coordinators, and municipalities to offer guidance at the start of an education collaboration between city and university.

- Subsequently, the research aims to develop an actor-network map to gain better understanding of the actors and their relations, and a detailed investigation of the learning process that is also enabled by that network.
- Ultimately, the research aims to develop design principles and interventions that support the learning process of students in the development of transdisciplinary competences in urban learning ecologies.

Lessons learned

The PhD research is still in its early stages and it is too soon to jump to practical advice to others. However, the conference paper ('Choosing challenges in challenge-based courses') has been presented during the SEFI Conference 2020 and already shows intermediate results of the project.

The research behind the paper showed the way that students choose a challenge at the start of a challenge-based course. One of the lessons learned is that students not only base their choice on the contents of the challenge, but also on the way the challenge might contribute to their learning trajectories and on the way the challenge will enable to make an impact on society.

Duration of the project

2019-2023.

Contact details

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Interdisciplinary Engineering Education

Guidelines for course design

About the project

To face the more complex societal challenges, interdisciplinary education is necessary instead of the usual disciplinary approach. However there are few practical guidelines on which to build interdisciplinary engineering curricula.

An interdisciplinary framework was used, validated in 4TU context, conceptualising constructive alignment between the educational vision, operationalised into pedagogical approaches and facilitated by support structures. All indicators for the analysis of educational design.

Nineteen, qualitative, semi-structured interviews were conducted with programme coordinators/ lecturers of courses described as interdisciplinary.

Objective

This study aims to provide guidelines for the design of interdisciplinary courses.

Outcomes or Deliverables

Prelimary results of 7 interviews indicate that interviewees struggle what interdisciplinarity is (vision) and how to design such a course.

Cognitive and collaboration skills are deemed necessary, but assessment thereof is unclear (education). Facilitation is hampered by the decentralised structure of the institute. Further analysis of the data is needed to provide clear guidelines for course design.

Dissemination:

- Perceptions of Interdisciplinary Learning: A qualitative approach article (REES 2019).
- Prerequisites for interdisciplinary Learning: Organisation and Staff article and presentation (CDIO 2020).

Lessons learned

- Valuing contributions to interdisciplinary teaching and researching in terms of appraisal, allotted time and budget, would boost the results of and willingness to adapt interdisciplinary ways of working.
- Non-departmental budgets which are available for interdisciplinary teaching and research could sustain the development of innovative solutions.
- A vision on what interdisciplinarity should be at an institutional level, helps the development of appropriate policy measures to sustain interdisciplinary teaching and learning.
- Different science fields bring different problem solving strategies to the table; e.g. technical fields focus on analytical and practical results, social fields on writing skills and philosophical reasoning.
- Interdisciplinary skills are particularly framed as group management and communication skills, the ability to integrate different disciplines and reduce complexity, using relevant information sources, process approaches, etc.
- Interdisciplinarity is not an aim in itself, it is subservient to solving problems in the best possible way, an interdisciplinary approach can help achieving this.

Duration of the project

The project will be completed in 2021.

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Theme

Maker Spaces

» Modern engineering education contexts allow for multiple stakeholders, links to society, learning at multiple locations, and using ICT in a smart way to support for this. How can educational ecosystems be best organised? What does learning look like in the so-called maker spaces, innovation spaces or incubators? How can extra-curricular experiences, such as challenges or living labs be linked to curricula or 'validated' via diplomas? The role of teachers, businesses and society must also be looked at and the way how to assess learning outcomes of such environments. Attention must also be paid to the role blended education and new technologies can play in effective rich learning processes and flexible and personal learning paths in engineering education. In Delft this theme has been and is focused on online design team spaces, learning in maker spaces environments and teacher support by design. This theme has overlap with the theme interdisciplinarity. However, the focal point here is on making/designing in engineering education.

Collaborative Design Lab for Education and Learning

Concurrent and integrated design in engineering education

About the project

Delft University of Technology is investing in Collaborative Design Labs for education purposes, which allow for concurrent and integrated product development activities in virtual learning environments. 4TU.CEE in collaboration with LDE-CEL, will appoint a combined PhD and teaching support for 5 years starting July 2020. Concurrent Design in Engineering Education focuses on improving the efficiency of students' engineering processes as well as training them in advanced, industry-relevant design techniques with a strong focus on team effort.

Specific use cases include, but are not limited to: facilitating bachelors design for system engineering projects and facilitating masters design studies. The lab will also facilitate collaborative design phases for student Dreamteams, graduate and undergraduate teams of TU Delft participating in competitions and challenges.

Objective

The proposed research project shall deliver empirical evidence for effects on student motivation, efficient collaboration of different team perspectives, gain of students on specific skills in design teams, as well as the embedded use of different collaboration and personalised learning facilities in a Collaborative Design Lab (CDL). The CDL shall be used as a 'design methods and -processes playground'.

Outcomes or Deliverables

From an educational perspective, the collaborative design process makes designing very motivating – it is a highly interactive, dynamic, fast paced method of design. Students can see the holistic result of their work at the end of each stage iteration, which can be in as little time as a single day. The instruction design has the power to facilitate near-instantaneous feedback on the consequences of design decisions at the mission and system level.

On a product or mission level, it enables to teach complex interactivity between customers and stakeholders and designers for a validated set of mission requirements and constraints. On a system level, it offers a powerful method to educate students on the inter-dependencies between subsystems, also using (internal and external) reviews as an important driving force.

Lessons learned

Preliminary findings in a pilot run were:

- Students become well versed in integrated design in engineering.
- It creates a rich exchange of ideas across various disciplines and across the world.
- Students' teamwork skills and open communication are engaged in novel ways relevant to professional development.

Duration of the project

2020-2025.

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Fine Tip Markers
Marqueurs à pointe fine

Maker Spaces and Learning

Why do maker spaces work?

About the project

Started in the '90s by MIT, the Michigan Institute of Technology set up the first FabLabs on-campus, which was followed by a huge success and spread out across 78 countries, with a network of 1000 locations. Like MIT, the 4TUs have numerous maker spaces, design factories, innovation spaces, learning spaces and so on.

Such university spaces all have slightly different purposes, but must include opportunities for students to: (1) run and try their own projects, (2) have (expensive) equipment available (machine driven locations), (3) the opportunity to meet, (4) co-participate and (5) ask guidance from academia and industry in the spaces available.

In this study the 22 maker spaces of TU Delft - spaces where making and reflection on the process of making and its results happen - are investigated. In this study the following question has been addressed: How do makerspaces offer pre-conditions for learning and to what extent do they contribute to student learning outcomes?

Objective

In this study the aim was to get insights on the current role and impact of maker spaces on student learning and the impact on the regular curriculum. The ambition is to provide policy or teaching advise for those involved in the organisation and creation of maker spaces.

Outcomes or Deliverables

The outcomes have learned that there are extensive differences in purpose, access, nature of the maker spaces at TU Delft. These differences impact the extent in which pre-conditions for learning of students is present and as a result for student learning to take place. The results will be presented in the near future.

Lessons learned

Students learn the most in a learning space when there is opportunity to learn from peers, or support staff and motivational factors are important to stimulate students to do their work. The more a maker space is student led, the more students learn from it. The TU Delft Dream hall is an excellent example.

- Prototyping is the most learned practical skill in the Model Making and Machine Lab (at the faculty of Industrial Design Engineering)
- Innovating and fast iteration as well as social learning took place mostly in the Dream hall

The curricular and industry link to maker spaces in Delft across the different spaces is still limited or might take place in other educational initiatives.

Duration of the project

The project will be completed in 2021.

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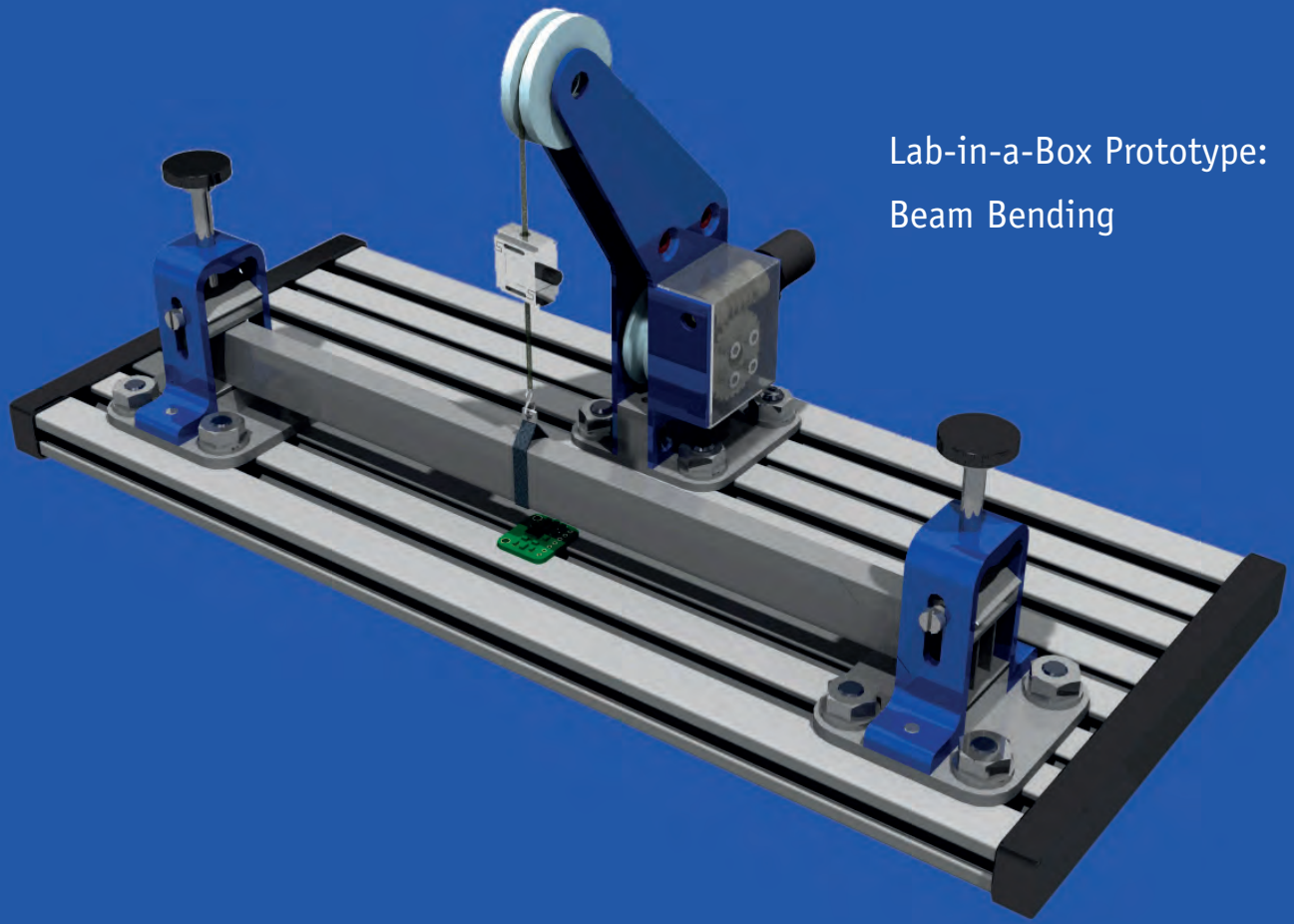

Lab-in-a-Box Prototype:
Beam Bending

Lab-in-a-Box for Structural Mechanics

Impact of hands-on experiences on learning enhancement in aerospace engineering

About the project

Structural Mechanics (SM) is a fundamental subject in engineering bachelor curricula. Because the discipline presents a high level of mathematical formalism, the curriculum usually focuses on deriving the equations that describe SM phenomena. However, students struggle at understanding SM core concepts only from formulae. Laboratory practice seems a promising addition to the course because it could help students link theory to events in a real-world environment and interact with multiple representations, which scaffold conceptual understanding.

Yet, with the great number of students in bachelor classes and lack of time and resources, it is often a problem to provide enough laboratory practice to everyone.

Moreover, to be effective, lab activities have to be carefully designed and implemented. For this reason, the project follows the Design-Based Educational Research approach, a methodology to improve educational practices while developing design principles and theories.

Objective

1) Design a low-cost portable lab for SM.
2) Investigate the impact of lab activities on conceptual understanding in SM.

Outcomes or Deliverables

1) Prototype of the portable set-up, tested by students and refined.
   The final version is expected to afford several different experiments on SM concepts and can be used in a normal classroom or at home, tackling the problem of providing lab practice to a large number of bachelor students.
2) Design principles for the development of the lab and the measurement of its effectiveness on student learning. This will allow the generalisation of the findings to other contexts (disciplines, faculties).

Lessons learned

- Prefer discovery style of laboratory instruction over the validation (cook-book) approach, because it scaffolds students' engagement with disciplinary concepts.
- Create the opportunity for students to directly observe and experience the phenomenon bypassing the analytical model. It allows students to arrive at an understanding of the phenomenon based on their observations.
- Develop data processing tasks based on the use of different representations, such as free body diagrams, infinitesimal cube, load-displacement plots, and strains distributions. Guide students in extracting information from representations; translating between types of representations and build one representation from another. Many representations beyond formulae are needed to fully characterise SM phenomena, especially for students who never experienced these phenomena before.
- In the final reflection, ask students to analyse data linking the observed physical events to the theoretical propositions. This helps students intertwine model and evidence-based reasoning and expanding their understanding of concepts.

Duration of the project

The project will be completed in 2021.

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PEER IMPACT AWARD
PEER IMPACT
1

Pilot EdMedia Lecturer Training Programme

Effectively embedding media in activity and assessment

About the project

Many lecturers would like to improve their teaching by making use of media that enhance their learners' experience. Fear that it might take a lot of time or not knowing which tools to use, can make it difficult to actually do so.

At TU Delft, lecturers had the opportunity to join in a ten week programme that helped them to effectively embed media in activity and assessment. This pilot, called EdMedia Protégé (EMP) programme was made possible by TU Delft Teaching and Learning Services and 4TU. Centre for Engineering Education. TU Delft was the first university in the Netherlands to pilot this development programme.

Objective

The EMP programme is designed to support lecturers who want to improve their ability to design and deliver media assets, such as infographics, video, graphic organizers, as an embedded part of teaching and learning. The EMP programme helps supporting an institution in why and how they embed media within their learners' experiences.

Outcomes or Deliverables

- One on one support for teachers from experts to help apply tools which resulted in personalized mind maps, videos and a lesson plan on how to embed media into teaching.
- Open source materials under the creative commons tools for others to use.
- Teachers learn to use free common tools and techniques.
- Monique van der Veen won the Peer Impact Award with her showcase at the end of the programme. She developed a mind map, a video overview for learners to use the Prezi effectively during their studies, and a lesson plan that describes how to embed the media into teaching.

Lessons learned

It is difficult to assess the impact of the use of media assets, since so many factors influence teaching and learning. But in general it can be said that the satisfaction of learners is higher. Lecturers feel they have more tools at hand to help students tackle difficult issues and are amazed that developing media assets is actually quite easy.

Duration of the project

The pilot programme has been completed.

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Education Hackathon

Co-creating the future of education

About the project

In October 2019 an Education hackathon challenge was organised by 4TU.CEE with support of LDE/CEL and the Teaching Academy. In 24 hours 'the future of education' was co-created together with students, innovators and educational enthusiasts. The hackers worked on 4 challenges introduced by lecturers of TU Delft.

They were supported by educational and business mentors. The challenges were: 1) How can we ensure individual students pass all learning goals in group work? 2) How can we track the team performance of student groups, with the input of students and coaches? 3) How can students take control of their own learning process? 4) How to support teachers in developing serious games good and quickly?

Objective

The aim of the Education Hackathon is to identify key challenges for education and co-create innovative solutions with students.

Outcomes or Deliverables

A handbook, written by Daniëlle Ceulemans, to organise similar hackathons is available on request.

The winning team designed a 'Teacher's Toolbox', a highly customisable online platform that lets lecturers create their own educational games and share them with their peers. They explored startup possibilities at YES!Delft.

The runner-up focused on solving the personal learning path challenge. That team had a follow-up meeting with their challenge owner. They inspired the Library with their solution for the Information Literacy course and are exploring to implement parts of their solution.

Lessons learned

The mentors were very enthusiastic about the student teams. The results were beyond their expectations and they experienced that the teams hardly needed any coaching, just some feedback.

The students were also very positive about the hackathon experience. They found that the challenge opened up their minds to new ideas and learned that if you set a goal, nothing is impossible. They also highly valued the feedback from the mentors.

Duration of the project

The hackathon has been completed.

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Theme

Student Learning

» In the first years of 4TU.CEE the theme self-regulated learning and math education have been taken up. PRIME, the Programme of Innovation in Mathematics Education, is and has been an ongoing project and is of the utmost importance for TU Delft. Lessons learned here can be applied in other areas.

Therefore 4TU.CEE has continued supporting the Prime project research, exploring self-regulation, gender differences, and transfer of math to engineering fields.

Educational Research in PRIME: Perceptions of Teacher Support

Basic needs, motivation, academic performance and drop-outs

About the project

In the Programme of Innovation in Mathematics Education (PRIME) research is done into the methods used in the education that has been developed. It involves cross-sectional research design in Q2 of the first year bachelor calculus course of computer science. Questionnaires are used to measure student perceptions of teacher support, basic psychological needs, satisfaction and motivation. Drop-out and performance information is collected after the course.

Objective

Recent research showed gender differences in student perceptions of teacher support. The present study aims to investigate these gender differences and their possible consequences for basic psychological needs, motivation, academic performance, and drop-outs. Gender differences in and the relationships between the above variables will be investigated.

Outcomes or Deliverables

We expect to find gender differences in basic psychological needs, satisfaction and motivation. Furthermore, we expect motivation to be positively related to academic performance and negatively related to drop-outs. Follow-up research could investigate the effectiveness of interventions in improving motivation and reducing possible gender differences.

A first paper has been published on 'Directed Learning in Math Education' (at CDIO 2019).

Lessons learned

Data analysis is currently in progress. Initial results and conclusion will be shared in the fall of 2020.

Duration of the project

The project is still ongoing.

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Educational Research in PRIME: Online Video Lectures

Enhancing the interactivity and effectiveness of learning from online video lectures

About the project

Videos are one of the most common instructional delivery methods in blended and online learning environments. In PRIME, pre-lecture videos are offered to students as preparatory learning materials before actual (online) lectures. The effectiveness of learning with videos has been widely debated by educational psychologists. Processing content from videos can be challenging because information presented in videos is transient, and hence, relevant information can be easily overlooked.

Therefore, learning from videos will only be effective if students are able to pay attention to the relevant information, review information when necessary as a function of self-monitoring, and use learning strategies to retain the new information. In this project, we will examine the effect of a number of scaffolds to facilitate self-monitoring of learning and use of effective learning strategies when learning from videos.

Objective

The aim of the study is to enhance students' learning performance by supporting self-monitoring of learning and use of effective learning strategies in video-based learning environment.

Outcomes or Deliverables

We expect that students who watch the videos embedded with questions and are asked to actively answer the questions before receiving feedback, will perform better than students who watch the videos embedded with the same questions but are given explanations of the solutions. We also expect that students who watch the videos without any embedded questions will perform less.

We will first use a small set of videos to empirically determine whether learning is more effective when the videos are embedded with the questions and feedback we have designed. Then, we will replicate the study using other videos before developing a set of design guidelines for math instructional videos.

Lessons learned

The study is to be conducted in Q1 of the academic year 2020-2021.

Duration of the project

The project is still ongoing.

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Educational Research in PRIME: Student Self-regulation

Are students self-regulated?

About the project

Blended and online learning offer students the flexibility of time and space to study. Therefore, to reap the benefits of such autonomous learning environments, students need to be capable of managing their study time and employ effective study strategies. However, research has demonstrated that many students are using study strategies that are not as effective (e.g., rereading) and their study schedules are mostly driven by deadlines.

Academic success is also strongly related to the use of study strategies and the extent to which students self-regulate their learning. As a consequence, it is important to examine the study strategies that students employ and to provide students with support that will optimise their study time.

Objective

The study aims to examine whether students use effective study strategies and whether the use of effective study strategies is associated with students' learning performance and self-efficacy in Math.

Outcomes or Deliverables

By identifying the study strategies students are using and how well students are using these study strategies, we could offer students targeted support to equip them with the awareness and knowledge of effective study strategies. Instructional support to enhance learning performance can also be added to the current learning materials to support the use of effective study strategies. For example, providing opportunities to practice recall when watching video lectures.

Lessons learned

The study is to be conducted in Q1 of the academic year 2020-2021.

Duration of the project

The project is still ongoing.

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Self-Regulation in Large Engineering Education Classes

How to foster student learning

About the project

In a large class, where there are more than 300-500 students at the same time, both teachers and students need to collaborate in order to make the process of learning exciting, fun, valuable and comfortable. Grading and feedback practices are no exclusion in this case. But how can a single teacher provide effective feedback for each and every student in a large learning environment? And should it be a teacher per se? What if students are actually able to self-direct their own learning? That is the focus of this PhD research.

Objective

To follow 1st year bachelor students in Computer Science and map how they evolve during their years at university into 'professional', dedicated, motivated learners and determine how they can be assisted in their learning path. While at the same time help teachers to make the process of learning more clear, enjoyable and somewhere a bit easier.

Outcome or Deliverables

The greatest ambition is to shift, or at least try to, the authority of assessment in the eyes of a student (and maybe even the teacher), in order for it to be a helping source for future development, instead of simple grading, stressful event.

Lessons learned

At this moment data collected from students is being analysed. At the same time data collection is being prepared for teachers and faculty policy makers. As soon as there are lessons learned, they will be shared with the 4TU.CEE community.

Duration of the project

From April 2018 till March 2023.

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Theme

Evidence Based

» The theme evidence based is addressed at request of the Board of Directors of TU Delft. Although this theme is mentioned separately it includes large components of future engineering skills.

Projects on ethics in engineering, critical thinking, academic skills, providing feedback for evaluative judgement, and stress in engineering education are being discussed here.


Ethics
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COMET

Comprehensive Ethics Teaching

About the project

With the growing awareness that ethics should play a key role in engineering education comes also the challenge of determining exactly how engineering ethics education should be designed and taught. COMET is a two-year research project that is focused on the future of engineering ethics education at TU Delft.

After looking back at the successes and challenges from the last 20 years of integrating ethics into the curriculum at TU Delft, our project develops best practices for ethics education going forward. One of our primary goals is to develop an account of moral sensitivity and how it can be fostered in engineering ethics education.

Though moral sensitivity is widely acknowledged as a key ethical competency it is less than clear how it should be understood qua concept and operationalized pedagogically.

Objective

Building a theoretical model that offers practical recommendations for teaching engineering ethics.

Outcomes or Deliverables

The project consists of three phases:

1) Laying a theoretical foundation through an overview of the state-of-the-art research on engineering ethics and engineering ethics education.

2) Developing our own tripartite framework for thinking about best practices in engineering ethics education, based on the establishment of three distinct but interrelated domains of ethical reflection important for the engineer (reflection on the moral dimensions of one's practical identity qua engineer, reflection on the moral significance of the structural-systemic context of the engineering practice, and reflection on the ethical impact of engineering activities, i.e. products, artifacts, designs).

3) Building off our theoretical model to articulate a useful notion of moral sensitivity and to offer practical recommendations – at the level of both form and content – for teaching engineering ethics at TU Delft.

One of the results is best short paper SEFI2020: Before responsible innovation: teaching anticipation as a competency for engineers.

Lessons learned

Our research thus far has consisted of a combination of literature reviews, philosophical conceptual analysis and some qualitative research in the form of a focus group that brought together engineering ethics educators from a wide range of universities from Europe, the USA, and Australia.

The main take away from the focus group is that nearly everyone involved in teaching ethics to engineering students agrees that the key learning objective is ultimately instilling a sense of engagement, care and sensitivity towards the ethical dimensions of engineering.

Though all focus group participants worked with syllabi full of different learning goals and objectives, it is ultimately the immeasurable 'click moment' in the students that everyone is after and that seems to matter especially

for a subject matter like ethics.

Another key take-away from the focus group is that nobody has found the golden recipe yet for how to effectively teach ethics as one small component of an otherwise technical or design-oriented curriculum. Supposedly this doesn't really translate into any practical advice when it comes to researching engineering ethics education, but it does underscore the urgency of such research.

Duration of the project

The project is still ongoing.

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COMET website

Image:Freepik

Critical Thinking in Engineering Education

Research and teaching

About the project

Critical thinking is generally acknowledged to be an essential skill for present and future engineers (Kamp, 2016). Although many course descriptions mention critical thinking, almost no courses at Dutch technical universities are entirely dedicated to the subject. Attention has to be paid to the unique ways normative and factual issues are intertwined in engineering matters, something hardly commented upon by the existing critical thinking literature.

Consequently we have had to develop a new book and teaching material that help engineers to perform their professional tasks which often require clear thinking and argumentation on a societal level.

Objective

This project aims to deliver ready-made course material for Critical Thinking for Engineers courses that meet the needs of teachers at the Dutch universities of technology.

Outcomes or Deliverables

The course material aims to cover:

- flexible lecture sheets easily adaptable to courses for all faculties
- accompanying lecture notes and book manuscript;
- elaborated cases from all faculties that serve the purposes of illustration or exercises of assignments;
- possibly modules for blended learning;
- multiple choice exam questions and other examination materials on paper and perhaps online.

Lessons learned

Many colleagues ranging from PhDs to professors at TU Delft attended our Critical Thinking workshop during the education day in 2019. This shows that many teachers are interested in the topic. During the event the definition, the topics, the skills and didactic methods were discussed.

Another lesson is that despite differences in emphasis, there is considerable overlap and consensus amongst the colleagues, who want to pay attention to critical thinking. All issues were connected to clear analysis of the facts of the problem situation and argumentation on the one hand, and on rational decision making in design or intervention on the other.

Furthermore according to evaluations, students (bachelor and master) are interested in the subject, and feel its relevance for their engineering abilities. Also, a Critical Thinking course on thesis propositions is popular amongst PhD students and is highly evaluated. The topic clearly resonates on many levels of TU Delft.

Duration of the project

This project in ongoing.

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PRESTO

Open asynchronous learning in virtual peer groups

About the project

In his educational fellowship, Pieter Bots of the faculty TPM aims to gain a better understanding of how students experience peer feedback and peer appraisal as part of their academic education. Five years ago, Bots developed the 'project relay' method to help students develop computational skills by individually and repeatedly iterating through a six step modelling cycle. According to Bots, students find it difficult and stressful to mark the work of their fellow students.

With 4TU.CEE a small research was done on operationalising 'Evaluative Judgement' realised within the project relay (PRESTO: open asynchronous learning in virtual peer groups). Evaluative judgment is the capacity to be able to judge the work of oneself and that of others, which implies developing knowledge about one's own assessment capability. The PRESTO online tool for providing peer feedback is one of those tools to stimulate evaluative judgement of students.

Objective

The aim of this project was to operationalise evaluative judgement in terms of how feedback has been formulated in the process cycle of PRESTO to incorporate evaluative judgement and how student's could best be supported to acquire this skill.

Outcomes or Deliverables

The analysis is realised and the results forthcoming within the coming year 2021.

Duration of the project

This project will be completed in 2021.

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Photo: Michiel Pouderoijen

Study Stress in Design Education

Towards the healthiest learning environment

About the project

Teaching physical design skills has long been the main building block of the bachelor curriculums at the TU Delft faculties of IDE and A&BE. We observe that our students achieve high level (design) competencies during their study time at TU Delft. But we also observe that design education too often goes together with over-aroused students and (over)ambitious teachers, leading to higher levels of student stress.

It goes without saying that this results in (the threat of) underperforming students, increased levels of student drop outs, and increased levels of student burn outs. This project contributes directly to the TU Delft agenda on study climate and student well-being, in which the executive board is looking for strategies to create both an ambitious and (mentally, physically and socially) healthy learning environment for students.

Objective

We aim to better understand study stress in design education, so that we as communities of learning and teaching can avoid unnecessary stress for design students in the future.

We will in particular explore issues of personal leadership, design pedagogies, assessment strategies, community building and communication, and the social and physical (studio!) environments.

Outcomes or Deliverables

The project will deliver a series of teaching guidelines for our staff and learning guidelines for our students in the format of a pattern book for Healthy-Challenging Design Education.

Lessons learned

It is easier said than done to not only have a good discussion about this theme, but also to (re)develop healthy-challenging design education. Stress is something that works differently for different people, and some levels of stress are actually needed to perform well. The most important thing might be to have a well-augmented and well-supported 'vehicle' – our pattern book – to talk about this sensitive topic with design students, design tutors and design project coordinators.

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Photo: Michiel Pouderoijen

Design Studio Pedagogies

Describing, evaluating, comparing

About the project

The studio is a pivotal pedagogical setting for teaching and learning to design in the faculties of IDE and ABE. But how do different studios define their focus and approach? How do they relate research to design? How do they integrate technology and engineering with spatial design and visual idea development? How do they refer to, or make use of, practice and stakeholders from practice? How do they make students reflect on their design and learning process?

Objective

The answers to the questions above are essential to not only better understand the similarities and differences between studios, but also to better understand the values and limitations of different studio pedagogies for student learning.

Outcomes or Deliverables

The outcome of this project is a well-documented and systematic description, evaluation and comparison of different design studio pedagogies from the master programs of the IDE and ABE faculties:

- Architecture
- Building technology
- Design for interaction
- Integrated product design
- Landscape architecture
- Strategic product design
- Urbanism

Lessons learned

It is not easy to get to such a 'well-documented and systematic description, evaluation and comparison' of studio pedagogies because design studio cultures are very often implicit and connected to individual design tutors or design project coordinators.

Duration of the project

This project will be completed in 2021.

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Photo: Michiel Pouderoijen

Academic Skills for Architects

The development of a handbook

About the project

Architecture[1] ('Bouwkunde') is a practical engineering science that focuses on solving socio-spatial-technical issues in the built environment. Academic skills focus to a large extent on assessing design situations, informing design decisions, underpinning design solutions, and critically reflect on design processes. Together with many faculty colleagues we clarify the pivotal academic skills for architects ('bouwkundigen').

Objective

The editorial board aims to develop a coherent overview of the pivotal academic skills for architects, as learning tool for our own bachelor students, but also as international benchmark for a theme that the field of Architecture has difficulties with to define and to explain.

Outcomes or Deliverables

The book Academic Skills for Architects sets the scene by first presenting architecture as scientific field within the engineering sciences, and secondly by presenting general conventions of scientific ways of working. Then it elaborately focuses on architecture specific academic skills and research methods, and it presents and discusses the relation between scientific research and academic design. Finally, the book shares insights in academic reflection approaches relevant for architects, with specific emphasis on design thinking and design processes, design implementation and stakeholders (practice, feasibility, entrepreneurship), and moral sensitivity and values for the built environment.

Lessons learned

The core knowledge question of the engineering sciences is 'does it work?' (my design, my prototype, my plan, my model), whereas empirical sciences deal with the core knowledge question 'is it true?'. Therefore, engineering sciences make use of a variety of less-traditional academic skills and research methods. This book is not only meant for our (bachelor) students as a handbook to refer to, but will also help our tutors with the further academicisation of our design oriented curriculums.

Duration of the project

The handbook will be available mid 2021.

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1] With 'architecture' we refer here to spatial design, planning and engineering in the built environment in a wider sense: architectural design, urban design and planning, building technology, architectural engineering, landscape architecture, management of the built environment

Photo: Michiel Pouderoijen

Seminar Research on Education Innovation

Experiences from the Delft Architecture & Built Environment community

About the seminar

In 2018 the faculty of Architecture and the Built Environment launched the Research-on-Education-Innovation initiative, which has grown into a programme with a large variety of innovation projects, research on education projects, and scientific publications.

This seminar which will be held in the academic year '20-'21 brings together the staff of the ABE faculty to present and further discuss our experiences on the themes of:

- design education;
- academic skills for 'bouwkundigen';
- blended/online education;
- multi-, inter- and transdisciplinary education.

Additionally, we will invite people from the 4TU. CEE community and external critics to reflect with us on our achievements in this programme so far, and our ambitions for the future.

Objective of the seminar

- to exchange and more systematically document our experiences on our research-on-education-innovation projects 2018-2020
- to reflect on our research-on-education-innovation portfolio of projects
- to inspire colleagues to contribute to this faculty-wide endeavour

Outcomes

We will deliver seminar proceedings with brief contributions presenting and discussing our faculty's education research and education innovation projects and ambitions.

Lessons learned

The ABE faculty feels the responsibility to educate its students best to its abilities. Evidence-informed education innovations play an important role to continuously improve and discuss the contents and pedagogies of our curriculums, studios and courses. But it is a huge challenge and learning experience for all of us to get from 'regular' education evaluations towards an educational-scientific approach towards teaching and learning. It asks for inter-disciplinary co-operation between us engineers and educational scientists.

Duration of the project

The seminar is about to take place in 2021.

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Website 'research on education innovation'

Theme

Computational Thinking

» Disruptive and emerging technologies are reshaping the world in which we live, and the laws and regulations that govern this innovation are changing just as quickly. Industry, businesses and higher education across the globe are struggling to keep pace with the challenges and opportunities presented by these technologies. Moreover, the current pandemic is incentivising the need for digital skills across the labour market. How can we use 'Emerging Technologies', such as Artificial Intelligence, mixed realities, Internet of Things, robotics, learning analytics, quantum technology as content and as tools for learning in higher engineering education to better prepare our students for their future? The urgency, the possibilities and limitations of emerging technologies are explored to improve the readiness of engineering students for educational practices and the labour market. Based on research we help the community to understand this phenomenon and to make better decisions with respect to teaching and learning. Technology is not an inherently 'good thing', but can offer a wide range of educational opportunities.

Think Q: Quantum Programming Education for Engineers

Teaching practical quantum programming for forward compatible engineers

About the project

Quantum computing is an emerging technology that has the potential to change the way we will be solving computational problems in the future (exponentially) faster. Although practical quantum computers are still very rare, education of the forward compatible engineer that is aware of the potential and able to apply quantum computing for solving his/her problems has to start today.

'Think Q: Quantum Programming Education for Engineers' aims at teaching the basics of quantum computing and skills in quantum programming to students of the engineering disciplines using a solution-oriented hands-on approach that makes the subject more accessible, also for non-quantum experts.

Objective

The main objectives of this project are to teach students the quantum computing principles and skills in applying quantum algorithms to solve computational problems from their discipline.

Outcomes or Deliverables

We have created the software framework LibKet[2] - The Quantum Expression Template Library, that provides ready-to-use quantum algorithms and building blocks that can be easily combined like Lego® bricks to create quantum-accelerated solutions for practical engineering problems.

Dissemination:

- A Cross-Platform Programming Framework for Quantum-Accelerated Scientific Computing. ICCS 2020. DOI: 10.1007/978-3-030-50433-5_35

Atop of LibKet, an educational tutorial will be developed in the cloud-based learning platform INGInious (https://inginious.ewi.tudelft.nl) that will allow engineering students and practitioners to explore the possibilities of quantum computing to speed up the solution of practical applications coming from their respective field of interest.

- It is planned to use this quantum education platform for the first time in a minitutorial at the SIAM Conference on Computational Science and Engineering (CSE21), March 1-5, 2021, Fort Worth Convention Center, Fort Worth, Texas U.S. minitutorial to the CSE21 bullet point.

The latest information on Libket can be found in the 4TU.CEE Innovation map.

Lessons learned

- The primary focus in quantum computing technology is still on developing the quantum hardware, which is admittedly a nontrivial task. However, it is the interplay of hardware and software that will make quantum computing a useful compute technology in the future. It is therefore advisable to involve future end-users, researchers and developers from the different computational sciences, early in the process to help them get prepared for the new technology and take into account their needs for the practical utilization of quantum computers.

- GPGPU computing has become an unprecedented success story over the last two centuries that clearly demonstrates how an emerging computing technology can revolutionize

the whole (high-performance) computing landscape. It might be wise to follow some of their good practices, e.g., provide easy-to-use software development environments and grant early access to new computing hardware via cloud-based services to support researchers in developing practical quantum algorithms; support the creation of quantum education and training centres (in the spirit of NVIDIA's CUDA Teaching Center).

Duration of the project

This project will be completed in 2021.

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2] In Dutch, 'Quantum' is spelled 'Kwantum', which explains the spelling LibKet. The name is an allusion to the famous bra-ket notation that is widely used for expressing quantum algorithms.

The Values and Risks of Emerging Technologies for Higher Engineering Education

A book to stimulate discussion

About the project

This project aims to develop a reader on the values and risks of emerging technologies in Higher Engineering Education. Artificial Intelligence seems to be the new engine for educational innovation with such emerging technologies as Adaptive Learning, XR (as AR, Virtual Reality, MR) technologies, Learning Analytics technologies, Computational Thinking and others. This datafication process challenges the current educational system, educational practice, ethical responsibilities, and not at the least big data use.

Years ago, education was overwhelmed by promises of learning technologies, now we know better and have to act better. We need to deepen our knowledge about the consequences of the datafication for learning and teaching to claim ownership and show involvement in educational innovation.

Objective

The objective of the book is to stimulate the discussion on the values and risks of emerging technologies for Higher Engineering Education.

Outcomes or Deliverables

This book is to stimulate and broaden the discussion to better decide about the value for education, to better understand the possibilities and limitations of these technologies and develop a better judgement about the industry involved.

The book will contain an opening chapter and approximately 10 papers covering the Emerging Technologies issue on course level, the level of the institution or policy level. This combination gives a rather broad overview of the issues at stake, when talking about the digitalisation of education.

Lessons learned

The lessons learned so far come partly from an explorative research (2019) done by 4TU.CEE on emerging technologies for education.
The main conclusions:

- Emerging technologies are expected to affect education more profoundly than anything before.
- To decide about the value for education we must develop an understanding of these technologies, which will allow students, teachers and institutions to judge if and how such technologies can help to improve teaching and learning.
- Due to the complexity, the diversity, the speed of development and the decay, education is challenged to develop an approach that can make these technologies work.
- For education to fully benefit from the opportunities it is eminent to develop a pro-active, sustainable strategy as part of an inter-institutional approach to deal with these challenges from an educational perspective.

Duration of the project

This project will be completed in 2021.

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Contact for:
- computational thinking and information technology driven engineering education, such as the possibilities of AI, VR, AR, and programming in engineering education.

Remon Rooij – r.m.rooij@tudelft.nl
Contact for:
- academic entrepreneurship that addresses creativity, opportunity seeking, creating value, risk taking, leadership and (self)management skills in engineering education.
- teaching excellence, professional development and careers in/via education.

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- challenge based education, that addresses issues of complex, open and authentic learning situations such as living labs and maker spaces, inter- and transdisciplinary education, future roles of engineers and the university of the future.
- educating for responsible engineering focusing on ethical skills for engineers which come with a growing concern for the environment, climate, health, fairness, inclusiveness, diversity and resilience.

www.4TU.nl/cee