

Entrepreneurial engineering education at 4TU



 **TU Delft**

TU/e EINDHOVEN
UNIVERSITY OF
TECHNOLOGY

UNIVERSITY OF TWENTE.

 **WAGENINGEN**
UNIVERSITY & RESEARCH

The authors



Simon Drolsbach

My name is Simon Drolsbach, and I am a student of the MSc Metropolitan Analysis, Design and Engineering, a joint degree at both the Wageningen University and the Delft University of Technology. Entrepreneurship is one of the themes that is engrained throughout the whole master programme. I think that developing an entrepreneurial mindset will become an increasingly important skill for students. I hope this brochure will give an insight into the possibilities of entrepreneurial education!



Merel Laarhoven

My name is Merel Laarhoven, and I am an Applied Physics and Sustainable Energy Technology student from the Eindhoven University of Technology. This project has shown a light on the existing entrepreneurship education at 4TU. I hope it will inspire teachers and students to make even more impact in the future. Besides this, I hope it will enrich existing education and allow every student to learn entrepreneurial skills throughout their study.



Alexandru Bala

My name is Alexandru Bala and I am currently pursuing my Master's Degree in Business Administration at the University of Twente. Being passionate about business and entrepreneurship, this project gave me more insight into the various entrepreneurial education aspects at the four technical universities in the Netherlands, especially regarding the two types of entrepreneurship education, namely *narrow* and *wide*.



Victor van Saltbommel

My name is Victor van Saltbommel and I am a student of the MSc Management, Economics, and Consumer Studies from the Wageningen University. During my master's degree, I followed the Entrepreneurship Track, wrote my thesis about the entrepreneurial mind-set, and did an internship at a start-up to apply an entrepreneurial way of thinking. This project allowed me to combine these different angles and transform insights into recommendations for further development of an entrepreneurial mind-set at the 4TU. Enjoy reading this inspiring brochure!

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Introduction

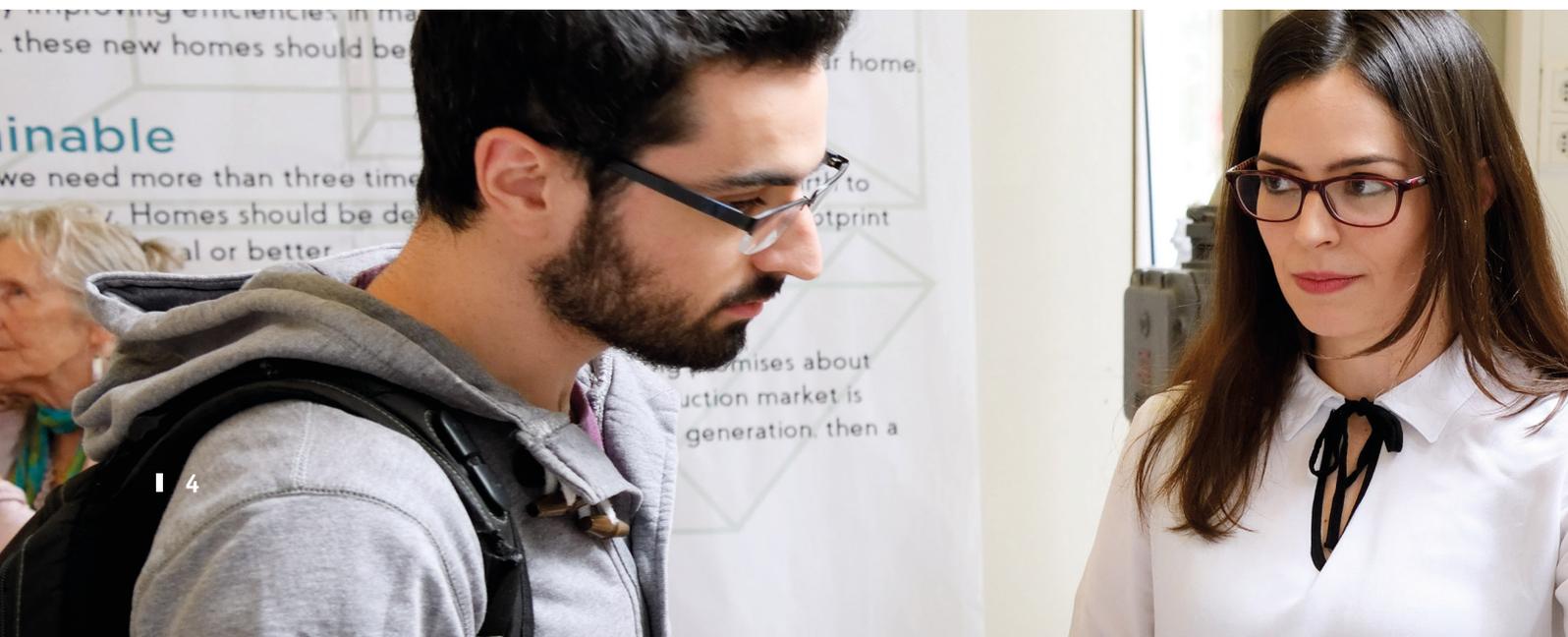
This brochure highlights entrepreneurial education aspects at the four universities of technology in the Netherlands (4TU), namely the Delft University of Technology, University of Twente, Wageningen University and Research, and the Eindhoven University of Technology. The brochure has been designed to inspire you to integrate entrepreneurship more in existing education, and thereby prepare students to be the engineers of the future. The brochure is part of the 4TU Centre for Engineering Education project '[Educating the entrepreneurial engineer](#)', which aims to develop education materials, modules, and courses on entrepreneurial engineering.

Narrow and wide entrepreneurship education

In recent entrepreneurship education, one could observe a shift from 'narrow' to 'wide' entrepreneurship education. In narrow entrepreneurship education the focus lies on business planning and venture creation. Wide entrepreneurship education focuses on getting skills and the entrepreneurial attitude: students are stimulated to act entrepreneurially while working on pressing societal challenges – such as climate change, AI, resource depletion, and migration. These are characterized by **uncertainty, complexity, ambiguity**, and challenge people on “getting out” of their comfort zone. Such learning processes are full of learning surprises – especially those unexpected moments with a lot of learning potential. This methodology facilitates implementing a new education approach, which calls for students to **team up** and cooperate with **external stakeholders** to create sustainable value. This is all done by an iterative and entrepreneurial process of opportunity identification, evaluation, and exploitation. By focusing on the **learning process**, entrepreneurship education can be interwoven within different (sub)-domains of engineering education. Hence, the content of wide entrepreneurship education can differ. Still, the process is similar – and, as such, it is comparable across contexts and the 4TU institutions.

Good examples of wide entrepreneurship education

This brochure contains 12 courses from all 4TUs selected as good examples of wide entrepreneurship education. Courses are selected based on the Entrepreneurship

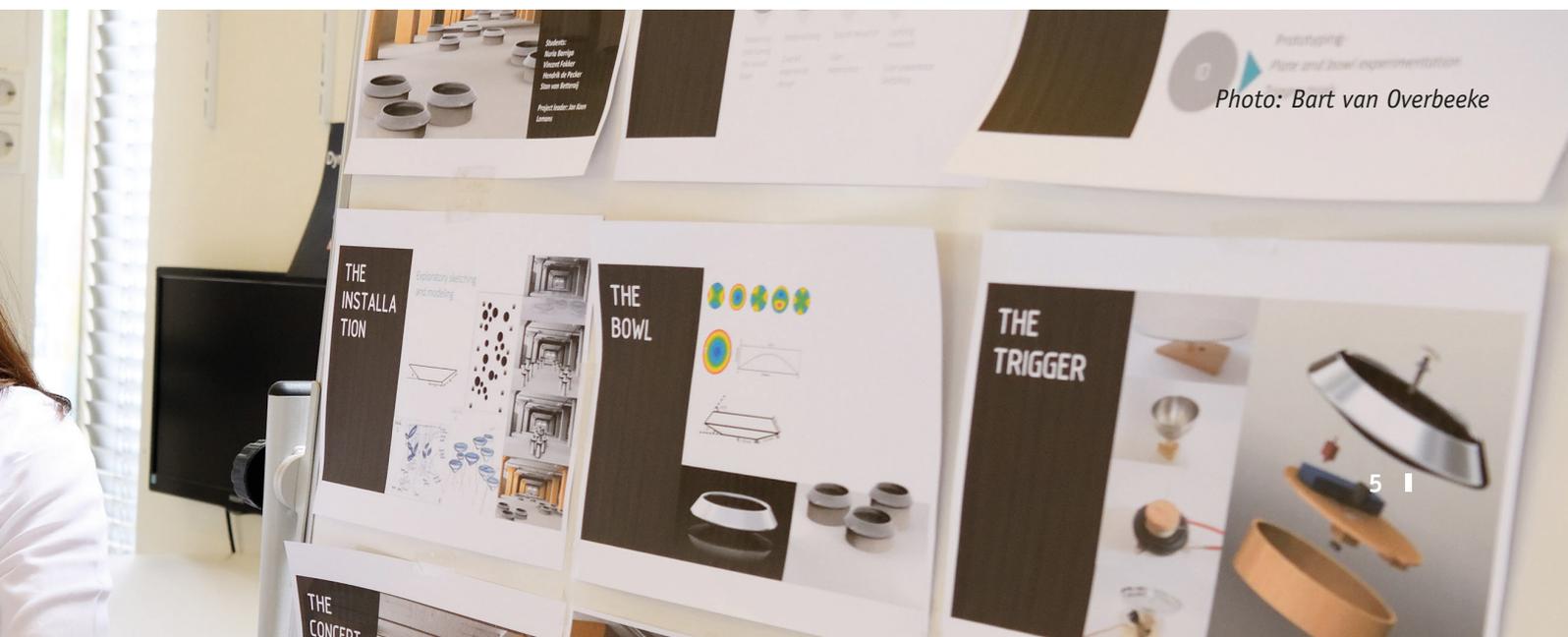


Education Canvas (Baggen, Lans, and Gulikers, 2021), which consists of design principles to help teachers create new, entrepreneurial courses and reflect on the existing ones. The Entrepreneurship Education Canvas offers a common language for systematically developing, evaluating, and implementing wide entrepreneurship education courses, programmes, and even progression lines across study programmes. It was mainly designed to integrate entrepreneurship in existing programmes, such that each student gets in contact with it. Some courses in this brochure offer a broader perspective than others do. Still, all of them provide an innovative way of teaching to open up education. All courses meet the three requirements educational programmes should meet to be called 'entrepreneurial': i) it accommodates the entrepreneurial process, meaning opportunity identification, evaluation, and exploration, ii) it includes authentic learning in the real world, and iii) in the course, value is created for others (Baggen, Lans, and Gulikers, 2021). Each university highlights one course with entrepreneurial elements as its core learning outcome. The second course focusses on the entrepreneurial mind-set while the third one seems not relate to entrepreneurship at first sight but contains hidden entrepreneurial elements. In this context, this brochure aims to provide insights into what entrepreneurship education entails and its strengths – significantly beyond the narrow and more traditional definition of entrepreneurship. These courses are categorised by employing different colours in this brochure.

Authentic learning

Entrepreneurship education is often part of **authentic learning**, such as challenge-based learning, design thinking, or experimental learning. This means that the below-stated courses can often be considered as an exemplification of these education forms. One aspect that is still not well established, however, is the assessment method. Since the process is more important than the output, it is often insufficient to have a final exam, report, or presentation to conduct a comprehensive assessment. That is why all 12 courses include their assessment format, which might inspire other courses in the future.

We hope that this brochure inspires educators and educational leaders to see where existing education could be augmented by focusing on the entrepreneurial mind-set. By developing this mind-set throughout their study programme, students will become the entrepreneurial engineers of the future, capable of dealing with ambiguities, uncertainties, and various unknowns related to the numerous challenges ahead.





Highlighted courses for the Delft University of Technology

The TU Delft hosts about 26,000 students in eight faculties. The motto of its current Strategic Framework, 'Impact for a Better Society', and related ambitions are closely aligned with the Sustainable Development Goals of the United Nations. For that purpose, TU Delft aims to balance "on the one hand, our pursuit of world-class academic excellence and, on the other, the expectations society has of us as a provider of life-enhancing education and expert solutions to societal problems" (TU Delft Strategic Framework 2018-2024).

Explicit entrepreneurship education started some 25 years ago. The [Delft Centre for Entrepreneurship](#) (DCE) offers dedicated MSc-courses and three BSc-minor programmes on entrepreneurship for all TU Delft students (Technology-Based Entrepreneurship, MedTech based Entrepreneurship, International Entrepreneurship & Development). In addition, many TU Delft teachers are residing in their own faculty that nowadays offer narrow and/or wide entrepreneurship courses, resulting in more than 60 courses on topics related to entrepreneurship. In addition, two MSc-programmes have a strong focus on 'wide' entrepreneurship, meaning they teach an entrepreneurial mindset, however, without explicitly referring to entrepreneurship: MSc Management of Technology (MoT) and MSc-Strategic Product Design (SPD).

Below three courses are highlighted that each provides a different perspective. The first focuses on narrow and educating through entrepreneurship; the second on wide and for. The third (game) on wide and about.

“ A significant part of the Architecture and Built Environment students will begin their own company - Architecture studio, consultancy firm, or building technology start-up - during or after their studies. It, therefore, makes sense to teach them in those fields as well”.

—
Hans Wamelink, TU Delft, 2021

Highlighted courses for the Delft University of Technology

Description

Keywords

Strong Points

Contact

Entrepreneurship in the Built Environment & BK-Launch Studio (MSc, 5 + 15 ECTS)

These two elective courses are newly set up in the Architecture & Built Environment faculty and could be seen as a package. In Entrepreneurship in the Built Environment, students are guided in developing their ideas for a self-owned company. Students learn about their own personal character, passion, knowledge, and learn to setup a business plan. The BK-Launch studio is a follow-up, smaller-scale design studio that focuses on developing a new business related to a challenge in the built environment. Students can select these courses if they are motivated to tackle the societal challenges of the present that have a strong relation to the built environment through new design ideas and innovative business initiatives. The BK-Launch Studio course can be seen as the last step in which students develop their own unique business idea in a “safe” environment and start a new venture. Students can win a “proof of concept fund” of 3,000,- euros to further develop their business idea. The strong point for both courses is the collaboration of lecturers with an entrepreneurial background (provided by the Delft Centre for Entrepreneurship) and the lecturers of Architecture & the Built Environment. In that way, students will learn the theoretical and practical basics of entrepreneurship, while also deepening the understanding of innovations within the built environment. The course assessment is based on an individual report and pitch including the final design and entrepreneurial plan, roadmap, and personal reflection.

entrepreneur motivation creativity
groups societal value

- + Skills that are related to an entrepreneurial mind-set
- + Collaboration between lecturers with an entrepreneurial background and “coaches” can guide the students in the built environment
- + Argumentation for added broader societal value and impact
- + Working together with students from different disciplines, but always with a focus on the built environment

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Design Strategy Project (MSc, 12 ECTS)

This course is part of the Master programme Strategic Product Design of the Industrial Design Engineering faculty. The course is compulsory for SPD students. The educational method of this course consists of two parts: 1) lectures on the theory and methods of Strategic Design, and 2) Project work in which the students learn how to apply the theory and methods in practice for actual companies. Students will analyse the challenges of an organisation regarding innovation, future risks, and current strategies to identify and frame a problem that must be solved. Students will then design a solution that will allow the organisation to grow with strategic intent. Lastly, students present an innovative and strategic direction to relevant stakeholders. After following this course, students will better understand the value and nature of strategic design on organisational innovation. Students will acquire management skills by communicating design outcomes with clients in a “design-wise” way and developing leadership. An essential aspect of this course is the collaboration with external companies. In this course, students will learn how to communicate with companies as clients. The assessment of the course is based on a presentation of the strategic advice for the company, plus a prototype, and a presentation of the results, supported by an animation or video clip.

design thinking prototype strategic design
management skills corporate client

- + Wide entrepreneurship through long-term strategic design thinking
- + Rethinking long-term challenges for companies
- + Intensive course, spanning over 20 weeks

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Game Design Project (MSc, 5 ECTS)

This course is part of the Master Complex Systems Engineering and Management of the Faculty of Technology, Policy & Management. Students gain experience with gaming simulation for serious use in this course, i.e., for policy- and decision support, organisation and management, and professional learning. Students develop their own (non-digital) game that applies to real-life or mock-up scenarios in decision/policy making. In the past, simulation games have been designed about transition to heat in Amsterdam, and disaster management in Ukraine. Experts (consultants and game designers) from the field give guest lectures on the history, future, design, and typology of Simulation Gaming. Although this course is not predefined as “entrepreneurial”, many wide entrepreneurship aspects are represented. The students will, for example, design a (prototype) of a simulation game to be used for learning, research or intervention and apply a game design cycle. As part of the assessment, students must write an essay about the topic they worked on. Students will be challenged to use their knowledge on simulation gaming to add value to existing organisations. Active participation during classes and workshops, evaluation of game design and project results, and essay quality are part of the assessment.

creativity group work prototype

- + Students learn how games can create value in different scenarios for corporations and organisations
- + Students get experience with the actual design of a product
- + Students develop a prototype and learn to assess based on its performance

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Spice



83 / EBP Innovation Space
Innovation Space

PARTECT

People who are suffering from Parkinson's disease have often problems with their locomotion. One of the dangerous effects that can occur is the 'freeze of gait'. It looks like the feet of the patient are glued to the ground and the patient can't move any further. The patient can lose balance and could fall, with all the associated consequences.

There is technology available to measure the walking behaviour of the patients in daily life, but these tests don't give the right results, since the patients are affected by the so-called "white coat syndrome". The patients behave differently in front of a clinician. We created a wearable system that can detect the freeze of gait in a daily life setting.

Within this interdisciplinary project, I focused on creating an unobtrusive wearable in which the sensor could be included for detecting the freeze of gait in a daily life setting. An important aspect was the location of the sensor.

Students: Tara Margelins, Cas van Groenou, Steven Klein, Sarah Trindler, Dean de Koster
Project Coach: Sigrid Broun
Expert: Aartout Brombacher (Client: LUMC)

Highlighted courses for the Eindhoven University of Technology

The Eindhoven University of Technology (TU/e) aims to prepare all its students for the future by developing a clear professional identity and help them to achieve sustainable employability. Challenge-Based Learning (CBL) is chosen as the center for TU/e education. CBL will give students deep knowledge, but it will also allow them to develop skills that enhance their employability. They will practice problem analysis and solving, creativity, critical thinking, and an innovative and entrepreneurial attitude/mind-set. TU/e innovation Space facilitates entrepreneurial learning on campus. Next to encouraging narrow entrepreneurship, focused on the launching and running of new businesses/start-ups, it also aims to support innovative activities on the part of established firms (intrapreneurship and corporate entrepreneurship), and support value creation for society (so, not only economic values) (wide entrepreneurship).

TU/e students can select courses related to entrepreneurship and the development of an entrepreneurial mind-set as elective courses, of which an overview can be found [here](#). They can choose for a certificate on entrepreneurship in the bachelor and in the master. Several User-Society-Enterprise learning lines of three 5 ECTS courses are developed to responsibly open students' engineering knowledge. Two examples are given below, next to an example of a Challenge-Based Learning course that focuses on developing of an entrepreneurial mind-set in the master.

“ The innovation Space plays a key role in my teaching as it offers me the space and inspiration to innovate my education and make it impactful. In the BSC course Responsible Innovation students work on real-world projects, supervised by societal stakeholders. The innovation Space offers the ideal platform and is a community of enthusiastic professionals and students who want to make an impact in the world and want to contribute to responsibly tackling the grand societal challenges of our times. I am happy and proud to be part of this.”

—
Johanna Höffken, 2020

Highlighted courses for the Eindhoven University of Technology

Description

Keywords

Strong Points

Contact

Entrepreneurship in Action (BSc, 5 ECTS)

This course aims to develop an entrepreneurial mind-set by designing a value proposition for a real given technological innovation. This is based on the entrepreneurial knowledge obtained from previous courses of this learning line. The value proposition contains an investigation of the technical feasibility, a market analysis, and the product's positioning in a solid business model.

The student teams receive feedback on their progress every two weeks in personal sessions with professional coaches. During the interim presentations, peer feedback is given as well. Lastly, a final report is written together with a presentation. These contain a thorough analysis of the process and an informed decision on whether or not to continue with a product based on this technology.

commercialisation

value proposition

group work

- + Multidisciplinary team
- + Professional coaches
- + Show accountability of decisions
- + Opportunity creation

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Innovation Space Project: Innovation and Entrepreneurship Processes (MSc, 10 ECTS)

Students learn to create an innovative and science-based solution to a real-life challenge in this course and incorporate this in a validated prototype. Starting from an open-ended challenge, students learn to deal with uncertainty and to develop an entrepreneurial mind-set. They investigate the system around the chosen problem and balance feasibility, desirability, and viability perspectives. By working in an interdisciplinary team, they bundle engineering disciplines to solve business, industrial, and social problem. The course does not consist of lectures but does contain out-of-the-box workshops and extensive collaboration with external organisations and real users.

Students reflect weekly on their personal and team development while getting feedback from peers and coaches. This personal feedback helps them to structure and steer their development and achievements. The final output consists of a pitch in front of a jury and external stakeholders and the final prototype, report, and a reflection on the learning objectives.

iterative learning hands-on
external collaborations

- + Design validated prototype
- + Project management skills
- + Hands-on approach
- + Collaboration with high-tech companies and societal organisations
- + Iterative experimentation

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USE Learning Line Responsible Innovation for the World (BSc, 3x5 ECTS)

In this learning line, students learn how to develop responsible innovations for the world. They work on real-life projects and are supervised by entrepreneurs and innovators from the private, public, and NGO sectors. Throughout three quartiles, they work in multidisciplinary student teams and develop concrete solutions based on theoretical and practical considerations. In their work, they learn why context matters, and they make concrete design decisions based on these insights. All this is guided by the overall goal to make sure that their responsible innovation actually lands in the world and makes an impact.

The assessment is based on a context dossier, a decisions matter book, a 'for the world' manual, presentations, and external evaluations. Often, teams continue their collaborations with their supervising organisations beyond the course, giving a new life to their projects after the learning line.

responsible innovation global contexts
real-life projects

- + Making real-life impact
- + Reflecting on analysis and action (called "reflection")
- + Communicating ideas
- + Teamwork (interdisciplinary & with external stakeholders)
- + Engagement, effort, and intrinsic motivation

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Highlighted courses for the University of Twente

The University Twente hosts about 12,000 students in four technical and one social science faculties. Its motto, “High Tech Human Touch,” as specified in its 2030 strategic mission of becoming the “ultimate people-first university of technology (that) empowers society through sustainable solutions.” To realise this mission, entrepreneurship education – also for engineers – plays an important role.

Focused entrepreneurship programmes are the Bachelor and Master in [Business Administration](#), the university-wide INN&ENT minor, the EIT minor, and the Creative Technology Bachelor. Entrepreneurship for engineers is taught not only at the programme level; in total, more than 90 courses contain elements of entrepreneurship, many of which are engineering courses. In addition, extracurricular activities, coaching, and mentoring are provided by key players of the University of Twente entrepreneurial ecosystem, such as [NovelT](#), the [Student Union](#), and others.

The University of Twente team considers the high degree of student-driven participation in the local ecosystem and the high degree of teacher professionalization (TELT, CELT, SUTQ, etc.), a distinct feature of the University of Twente entrepreneurship education.

“ Four times in a row, the University of Twente (UT) has been named the most entrepreneurial university in the Netherlands. The flexible and low-threshold support provided by the UT gives students a unique opportunity to develop further within the entrepreneurial climate in addition to and during their studies. The Student Union is responsible for policy in the field of student entrepreneurship at the UT, students are responsible for what students are offered which makes the various parties fully integrated into the student society. The Student Union is happy to contribute to the development around entrepreneurship, the entrepreneurial character of the UT and the entrepreneurial attitude of students.”

—
Eline Kikkert, 2021

Highlighted courses for the University of Twente

Description

Keywords

Strong Points

Contact

Design Thinking for Service and Business Innovation (MSc, 5 ECTS)

As the world becomes more globalised, customers more engaged, and technology and the internet ubiquitous, the complexity of the post-industrial markets requires new approaches to support the development of competitive advantages. In that context, Design Thinking provides tools and methods to support customer-centric innovation, which considers the viability, feasibility, and desirability of new offerings. That is Design Thinking balances market demands with the business strategy and organisational capabilities.

In this course, students learn Design Thinking from its academic origins – that is, the study of the designed ways of thinking, the nature of design problems, and the unique ways in which design can tackle complex problems – to the contemporary managerial perspective focused on the development of design capabilities in organisations.

The course is structured in a transdisciplinary fashion. Students from business, design, and technology backgrounds cooperate to address complex challenges facing organisations. To balance autonomy and structure, the course combines lectures with a practical design challenge.

Assessment is based on a group project and an individual essay. The essay adds to 30% of the final grade and the project 70%.

complex problems

business innovation

design thinking

- + Transdisciplinary teams
- + Design Thinking for solving complex problems
- + Transform knowledge into skills through practice

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Nanotechnology Design Project (MSc, 10 ECTS)

In this course, students work in groups of 4 – 6 people to design a nano-device of their own choice and consider business aspects/opportunities for this device. The project starts with a small number of lectures to define and explain the physical “domains” involved. Focus is on the fields of micro electromechanical devices, Lab-on-a-Chip, and (unconventional) nano-electronics. After this, literature research is carried out to get an overview of the state-of-the-art in the field of choice. Basic functionality and requirements are formulated next. A possible implementation is then proposed (“conceptual design”), after which detailed modelling is carried out to help define exact dimensions, material choice, and driving parameters (electrical, hydraulic). Finally, a (clean room) process flow is developed for the device fabrication. Significant phases in the design are presented by the groups and evaluated by the lecturers.

Besides the presentations, deliverables are a literature report and a design report, including all critical phases of the design process (conceptual design, physical design, process flow design, and mask design). Parallel to the technical design, the groups try to develop a business case for their device of choice. Important milestones are the initial business canvas presentation and the final business pitch.

The final grade will consist of a group project (100%).

technology entrepreneurship

design of nanotechnology-based devices

- + Carry out systematic literature research to determine the state-of-the-art
- + Learn about and apply basics of finance for entrepreneurs such as the cost model, the revenue model, and basics of venture valuation
- + Familiarise with the Lean Start-up Methodology such as the build-measure-learn loop and the utilisation of the Lean Canvas

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Industry 4.0 with Human Touch (BSc, 15 ECTS)

At this moment, a significant change in the industry occurs, the so-called fourth industrial revolution. This revolution involves advances in underlying technologies, e.g., production and ICT, changes in firms’ business models. It is likely to profoundly impact our society. New manufacturing technologies, extensive digitisation, and the interweaving of machines and organisations (Internet of Things) significantly impact the industry. This minor “Industry 4.0 with Human Touch” gives an overview of several fields of interest that have implications for this fourth industrial revolution. It prepares students for their future in state-of-the-art industries. The minor is divided into courses related to technology, computer science, business, and society. In the end, a project brings all these topics together.

This minor consists of 4 elective courses, where to choose 3 out of 4. The choice depends on the educational background of the student.

A plenary part introduces Industry 4.0 and how it evolved from the industrial revolution 3.0 to where it is now and will be in the future. The four fields of interest, technology, business, computer science, and society, are explained and their relation with each other and with Industry 4.0.

Assessment is as follows: test for Technology (3 EC), Business (3 EC), Computer Science (3 EC), and Society (3 EC) + project combining the four disciplines (6 EC).

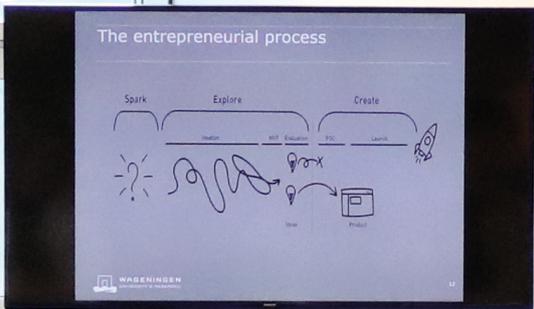
company maturity

innovation

business models

- + Combination of 4 important disciplines
- + The project consists of research at a company
- + 15 EC

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STA

Highlighted courses for Wageningen University & Research

Wageningen University & Research hosts about 12.000 students in five [departments](#): Agrotechnology and Food Sciences, Animal Sciences, Environmental Sciences, Plant Sciences, and Social Sciences. It aims 'to explore the potential of nature to improve the quality of life' by developing innovative technological, social, and nature-based solutions in the domain of healthy food and living environment (Strategic Plan 2019-2022).

Entrepreneurship is one of the four anchors of the staff department Corporate Value Creation (CVC). It is brought together in E'ship@WUR. The WUR aims to generate an impact on society by fostering wide entrepreneurship education. E'ship@WUR stimulates entrepreneurship by offering entrepreneurship education in various forms of integrating entrepreneurship courses in students' individual programmes; mostly taking place in electives. Some of these electives are combined in the [Entrepreneurship-Track](#), a comprehensive Master programme that students can follow, or in the [Minor Innovation and Entrepreneurship](#) for Bachelor students.

The ambition is to gradually integrate *the entrepreneurial way of teaching* in all programmes to support the transition to wide entrepreneurship education. Therefore, the WUR focuses on raising students and staff awareness on entrepreneurship to develop a more multi-contextual entrepreneurial mind-set.

“ StartHub Wageningen is the start-up incubator and educator for students, PhD's and recent graduates of Wageningen University & Research. Our core focus is development of entrepreneurial competences of students and student entrepreneurs. StartHub supports passionate students to explore their individual potential and introduces them to the challenges of starting up a business. I believe it is unique to have a place where you can just walk in and say: “ 'I've got an idea, but I don't know where to start. Can you help me?“. I feel very lucky to have contributed to many students' potential to make a positive impact on our planet with the knowledge they have.”

—
Friso Schut, Student Board [StartHub Wageningen](#) 2020-2021

Highlighted courses for Wageningen University & Research

Description

Keywords

Strong Points

Contact

Building Entrepreneurial Teams (MSc, 6 ECTS)

In this interdisciplinary course a multilevel perspective on the management and development of human competencies is taken; competencies in general and entrepreneurial leadership and an entrepreneurial workforce in particular. The course aims to teach that entrepreneurship and intrapreneurship are primarily dependent on human efforts - and specifically on teams. Attracting, managing, and developing competencies such as identifying new opportunities and realising entrepreneurial goals are essential. The interactive, entrepreneurial and authentic character of the course challenges students to develop their entrepreneurial mind-set.

Students are assessed as a team, for their work on an advisory report for a real start-up team or a team that is part of an existing organisation (e.g., in the agro-food/life sciences) (40%); pitch about the entrepreneurial learning journey (10%; 50% teachers, 50% peer-team), individual written open book exam; case-based, reflection- and theory-based tasks (50%).

entrepreneurial mind-set

real-life cases

experimental learning

- + Authenticity & learning-by-doing: the students design and actually implement a learning intervention with the real team they consult
- + One of the few courses that emphasize the importance of an (entrepreneurial) team
- + Interactive & peer feedback
- + Highly rated by students in its evaluation report on e.g. satisfaction level, new knowledge acquisition, and/or skills and engagement

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“ I liked that it was different than other courses. We were with fewer students which created a safe/comfortable atmosphere, so I felt comfortable speaking out loud. Due to the different set-up (not just theory lectures), I learned a lot more” - a student

Case Studies on Product Quality (BSc, 6 ECTS)

In this course, groups of students work on case studies derived from industrial practice or scientific interest (problem-oriented). Product quality and opportunities for product and process improvement are central to each case study. The course aims to learn how to apply basic knowledge from various disciplines in food technology to define and improve food product quality. Overall, the course is a clear example of wide entrepreneurship education where related elements are assessed in the group work part. Entrepreneurial thinking is emphasized during an entrepreneurial workshop that forms the basis of a 'Valorisation Chapter' in the final report.

Assessment of this course is divided in: group work (competence & effort)(25%), case implementation (integrate different disciplines)(25%), report & presentation (50%).

case studies problem-based learning
product- and process innovation

- + Very extensive thesis- and internship-like assessment rubric with entrepreneurial elements such as commitment and perseverance, creativity, initiative/independence
- + Collaboration with experts (interviews) and academic supervisors per group
- + The course aims to integrate higher levels of uncertainty and complexity and can be characterized by its high alignment with external stakeholders (i.e. commissioner and supervisor)
- + Budget (EUR 125,-) for project associated costs

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Bioprocess Design (MSc, 12 ECTS)

Students will work in a multidisciplinary team to design a new and innovative biotechnical product and the associated production process in this course. Most often biotechnology companies or other interested parties from outside Wageningen University are involved as external project directors, who ask the student team to generate ideas for these projects and work out the ideas in more detail. The course aims to teach students to work together in a multidisciplinary and multicultural project team (8-9 MSc students) on a designed oriented biotechnological project in a professional environment. Overall, this course can be described as domain-specific entrepreneurship education where entrepreneurship is not in the nature of the course. Still, it is part of the whole learning process as students have to design a business plan or research proposal.

The course is assessed by written contracts and intermediate progress reports (20%), final reports and convincing oral presentations (40%), teamwork (20%), individual performance as a team member (20%).

problem-based learning multidisciplinary teams
product- and process innovation

- + 12 ECTS, so full-time involved in the process
- + Multidisciplinary and multicultural teams
- + Technical course that also focuses on the economic perspective and company's business strategy
- + Each team has a team coach and project director (selected lecturers)

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Potential for further developing an entrepreneurial mind-set at 4TU

While analysing wide entrepreneurship at the 4TU, we found that:

- The twelve highlighted courses mainly have a low score on complexity and uncertainty in the category 'context and relationships' of the Entrepreneurship Education Canvas.
- Uncertainty and ambiguity are not explicitly mentioned in the description of many course guides as fixed entities. They are often not necessarily part of the entrepreneurial learning process of students.
- Almost all courses include (interdisciplinary) teamwork, and many courses cooperate with external stakeholders.
- Concerning the assessment method, it is helpful to involve coaches or experts, embed peer feedback, and reflect more on the learning journey throughout the project by, e.g., doing an intermediate assessment.
- It is beneficial to work on authentic/real-world problems when students are full-time involved during a semester. However, it should be noted that the actual impact students make is not always clear. Therefore, a lesson learned is to not provide hypothetical cases that do not create a real impact on, e.g., a system or society.

Having these findings in mind, we come to the following recommendations for further developing wide entrepreneurship education at the 4TU:

- Increase the level of uncertainty and ambiguity in the learning process of courses. This can be done by increasing the number of decisions regarding an entrepreneurial process that needs to be taken when information is incomplete or ambiguous. It should be taken into account here that this might not be appealing to students but is essential for developing an entrepreneurial mind-set.
- Emphasize critical self-reflection and specific lessons learned concerning the entrepreneurial learning process on an individual- and team level. Role models (e.g. alumni or entrepreneurial students) with an entrepreneurial mind-set and operating in different contexts can inspire.
- Achieve high levels of alignment with external stakeholders and emphasize co-creation. Authentic and complex entrepreneurial challenges together with, e.g., enthusiastic and involved commissioners will contribute to the motivation and outcome of students.
- Explain the context of the value creation process that takes place and the impact students can make on a local, regional, (inter)national, or systemic level in various contexts (e.g. financial-, social-, cultural- or ecological domains). This can increase the relevance of a project and students' motivation.

Joint degrees and extracurricular activities

Although this brochure focused specifically on wide entrepreneurship education at the individual universities of 4TU, we are aware that there are more ways to develop entrepreneurial skills in various contexts. A great example of an interdisciplinary programme of the WUR and TU Delft that focuses on sustainable urban development and includes entrepreneurship courses in the master's is Metropolitan Analysis, Design, and Engineering ([MSc MADE](#)). Besides this example of a joint degree, there are multiple 'student teams' ([TU/e1](#), [TU/e2](#)), 'Dreamteams' ([TUD](#), [UT](#)), and 'student challenges' ([WUR](#)) where students are working on (global) societal challenges in different projects to come up with solutions that are shaped by an entrepreneurial way of thinking. Often, these teams even take part in international student competitions. As these extracurricular programmes focus on developing an entrepreneurial mind-set, we recommend stimulating the discussion on students' specific competences while working on the challenges and how to embrace this in entrepreneurship education.

References

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Contact details

Below you can find the contact details of the 4TU.CEE team that worked on this brochure. The brochure is part of the 4TU.CEE project '[Educating the entrepreneurial engineer](#)', which aims to develop education materials, modules, and courses on entrepreneurial engineering.

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