cdio European Regional Meeting 2016

3TU. CENTRE FOR ENGINEERING EDUCATION

Inventing Tomorrow's Engineering Education

Summary

Delft | 25 & 26 January 2016

Keynotes:

Presentations of parallel sessions:

In this document you will find summaries of the presentations that were given during the CDIO Conference "Inventing Tomorrow's Engineering Education'. Many of the presentations are also made available on the 3TU.CEE website.

Keynotes

War on Talent: a Reality

Drs. G.L.M. Hamers, President & CEO Vanderlande Industries

In his keynote mr. Hamers, President and CEO of a hightech company with over 4000 employees worldwide highlighted that motivated and skilled staff is increasingly becoming a differentiator in industry. He called for more entrepreneurship, (intercultural) communication and management skills in the curriculum, and to pay more attention to the "common sense" in industry: dealing with risks, when is good, good enough? Obviously technical know-how is remains crucial, but disciplinary knowledge alone is not discerning anymore: additional competences and skills are necessary to succeed in the future industry. The most important missing skill for engineers is the ability to work in a(n) (intercultural) team. He experienced this himself when he first entered the job market with a degree in experimental physics, and straight away started an MBA course to gain missing skills like management and communication. He pleads for an MBA light course as part of the engineering curriculum. It doesn't mean that his technical degree was useless. Although he felt inadequately equipped to carry out is first job as business manager at Fokker, he still benefits from his technical background: "I translate problems and challenges into models to make them more manageable".

Highly needed kills of engineers according to Hamers:

Source: Vanderlande Industries presentation 'War on Talent: a Reality'

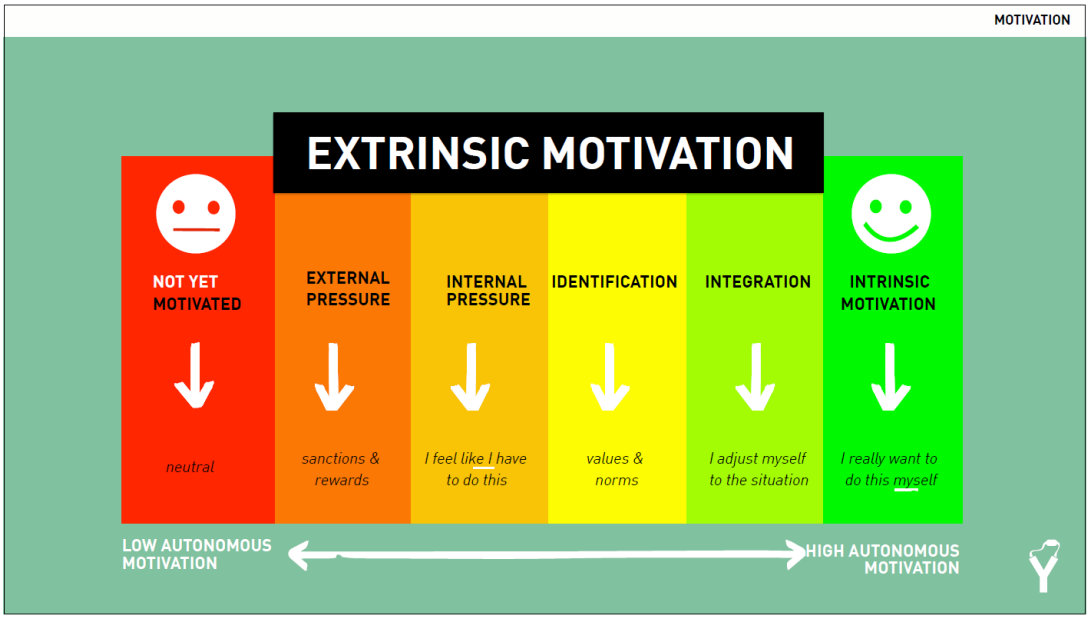
Future Generation of Engineering Students

Yvonne van Sark, Youngworks

Yvonne van Sark, co-owner and advisor at Youngworks, agency for youth communication, inspired the participants with insights about trends amongst the new generation of adolescents that is about to enter our classrooms. Although there are many similarities in adolescents, no matter what generation, about 20%

of issues is different. She mentioned three trends: Partycipation is the will of adolescents to be involved in how things are organised, to co-create. They do not want to be passive consumers. Maximisation is another trend. They want to make the best of their life. Interesting is also what Dutch parents find most important in education: they want their children to be autonomous and assertive. Another trend is that adolescents want to be more entrepreneurial. A fourth trend, which is also a great challenge, is the attention span amongst youngsters. Intensifying the 'attention span' amongst youth is an educational challenge. To do so students need to have intrinsic motivation. She outlined possibilities for education on how to stimulate this motivation by paying attention to competence, co-creation, relatedness and autonomy.

Extrinsic versus intrinsic motivation according to Yvonne van Sark:



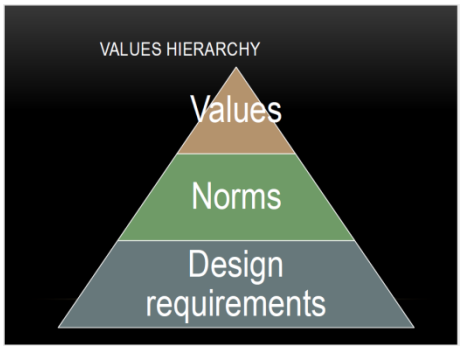
Source: Youngworks presentation ' Future Generation of Engineering Students'

Engineering Ethics

Prof. dr. Jeroen van den Hoven, Dean faculty of Technology, Policy and Management, Values Technology and Innovation at TU Delft

Jeroen van den Hoven, professor of Ethics and Technology focused on responsible innovation and value sensitive design in his keynote. The 21st century knows grand challenges in fields such as global sustainability, mobility, poverty reduction, climate change. Engineering is involved in the origin of these problems but also part of the solution. Engineers need to know where they fit in. They need to innovate responsibly and bring ethics down to design requirements by learning to think about the outcomes of technology, to think about moral requirements. Moral thinking opens up new innovations, but with it there is also a threat of moral overload. The values hierarchy makes a discussion tangible.

If you bring ethics and engineering together at an early stage, moral values like privacy and autonomy can be included in the design phase of new systems, technologies and applications. This is what we like to teach our students.

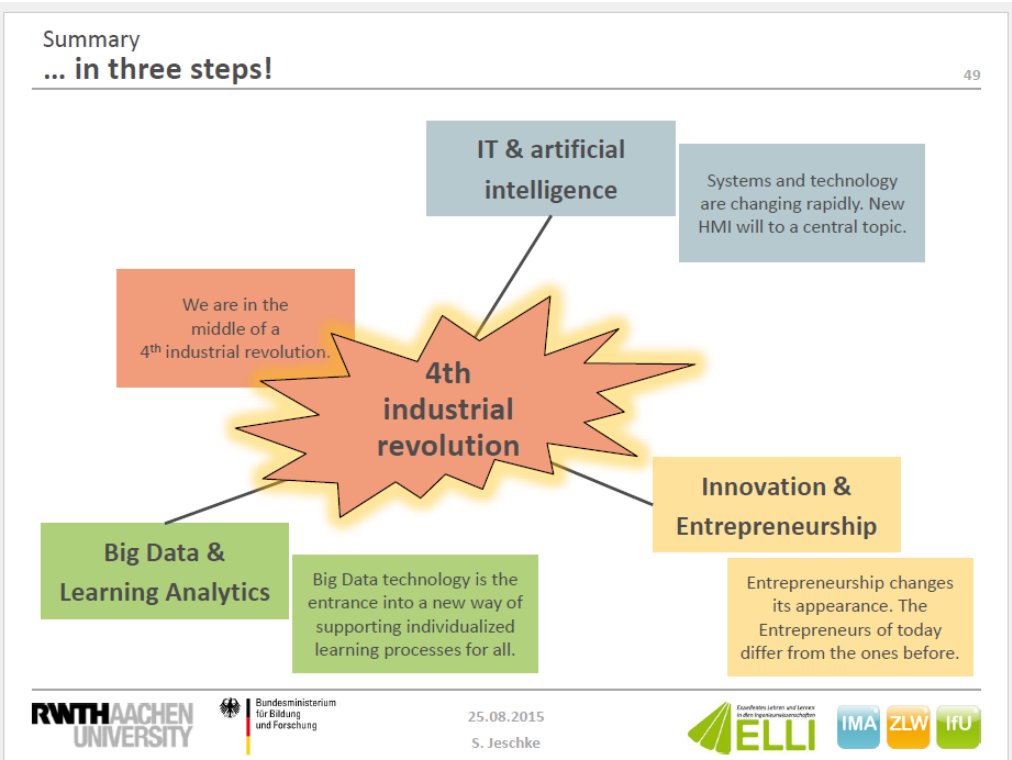


Source: Van den Hoven, presentation ' Engineering Ethics: Responsible Innovation & Value Sensitive Design'

Engineering Education for Industry 4.0

Sabina Jeschke, Vice-Dean RWTH Aachen University

Industry 4.0 is the new era of artificial intelligence that drives strong societal change. Technology drives innovations. This has implications for future engineering education. Engineers must be able to excel through interdisciplinarity, be able to adapt to rapid innovation cycles ànd survival in industry requires IT skills: 'They need to be able to speak code'. To become industry 4.0 engineers need entrepreneurial skills, learn to deal with risks and uncertainty an above all burst with creativity to come up with innovations according to Jeschke. Higher education institutions need to respond to the individualisation trend, offer flexible curriculums. A shift towards more interactive and collaborative components within higher educational e-learning is absolutely necessary and education institutions need to set new rules in accessing students' data, respecting privacy.



Source: Jeschke, presentation ' Engineering Education for Industry 4.0'

Parallel sessions

Blended Learning in Continuous Professional Staff Development

Suzanne Hallenga-Brink

In a workshop on blended learning by the Hague Applied University we were split up in four groups to make a story board for a blended course, and discussed how to deal with professionalisation, what type of assessment is available in blended learning and working methods in blended learning. The assessment showed that blended learning offers the possibility to approach assessment with different tools and opening up a vista of new ways of working. Such as video pitches to present group or individual results to the group and have a peer assessment on the results. Pitch to peer may be good example of this principle. Reflection blogs, or the use of learning analytics may be other way to assess in blended environments. The key question remained how to use the assessment as formative or summative assessment and how to assess in a reliable and valid way. The professionalisation group pinpointed the policy obstacles, yet showed that these tend to be hordes (bears) along the way that can be overcome. Engagement by blending the professionalisation to show its relevance seems to be a commonly held opinion.

A separate wrap up document has been made. To view it click here. For more information please contact Marja Bakker at: info@2blearning.com.

Engineering Education in 2030

Aldert Kamp

In the workshop given by Aldert Kamp we were engaged in a vision on the rapidly changing world, what this implied for what students should learn and how this should be embedded in our curricula. Participants were invited to determine what profiles would be needed on top of the disciplinary knowledge in engineering education. An engaged discussion amongst four sub-groups resulted in e.g. the idea that we would need innovating entrepreneurs, scientists and those who are prepared for industry. Another suggestion was to adapt the learning process to the type of skills/knowledge needed such that new profiles could emerge from this future new setting in which authentic, collaborative learning with interdisciplinary experts would all be confronted with the grand engineering challenge. A third group felt that 15 minutes was too short to discuss such an important question. They are right Kamp finished with a very brief result of what “Free Spirits Think Tank” took half a year to realise. These Engineering Profiles for the future will be revealed more fully at the Turku CDIO conference.

Engineering Education Research

Kristina Edström

During this session we tried to answer two questions:
- Engineering Education Research (EER), why do we do it and what is the purpose?
- What is quality of Engineering Education Research?

The participants discussed in small groups and reported back on the outcomes.
Several groups stated that Engineering Education Research is about improving engineering education. To understand how it works and why it works and try to improve it. The engineering attitude is very important in this. We need to learn from our successes and failures, therefore we need to share knowledge and communicate. The necessity for an Engineering Education Research Community was felt.

A side note that was made:

Sefi has an EER-group as well. Sefi values this very highly. People from the EER community are welcome to join the Sefi community.

Engineering Specific Opportunities in Online Education

- Online Education at TU Delft Willem van Valkenburg

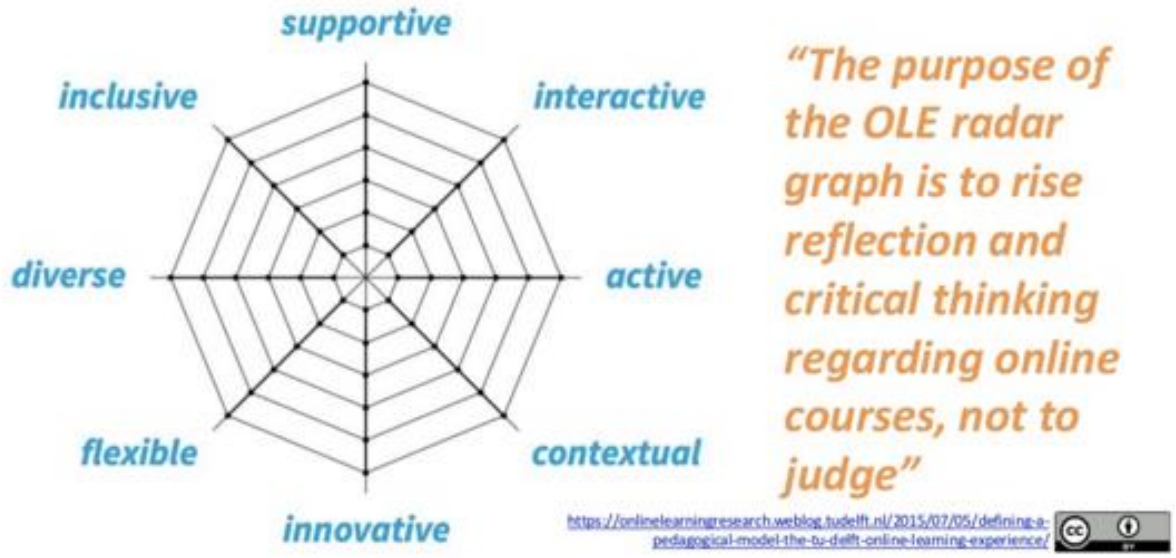
During this session Willem van Valkenburg, director of the TU-D Extension School presented his work.

The TUD Extension school has as a goal to educate the world & improve the quality of education. They do this with several platforms:

1. OpenCourseWare = free, open licenced course materials. 160 courses online, 1400 visits per day. Lot of self-learners use it. Just materials, no interaction with the teachers
2. MOOCs: free, for 10.000 students, EDx. Everything is automated
3. ProfEds: paid. focus on lifelong learners. The more interaction with the teacher, the higher the fee. Participants do not get a certificate, but continuous education units.
4. Online Courses: Full master degree (water manager)

The developed online are all used in a blended way on campus as well.

They use a pedagogical model: You can plot your course on it. This spider web is a tool to check whether you have everything.



The team consists of an e-learning developer, instructional designer, multi-media expert, studio facilities, copyright experts, assessment experts, proctored exams, evaluations (every course is evaluated within a month after the course, so the improvement cycle is possible), teacher training (a lot of training is provided, so there is a module to teach online and this is an online course as well. Last but not least: there is a marketing team to reach the learners to the online platforms.

Results of the Delft Learning Community:

- Teachers involved
- Learning outcomes
- International learners (really active)
- Impact: Mooc has a positive effect on campus education (http://www.e-learn.nl/2015/01/11/mooc-has-positive-effect-on-campus-education)

- Teaching an active online master course in linear Modelling Sonell Shroff

Dr. Sonell, the other speaker in this workshop showed us how she blended her course in a way that was fast, but invasive as well. The course is CDIO-proof and consisted of two parts. Theory and Practice. The theory part is the Conceive and Develop part, the practice is the Implement and Operationalise part.

It was a running course, with 120 registrations. The theory classes, are given live, and they are recorded and put online. The practical problems were all real life problems. Dr. Sonell gave us an insight in her successes and failures. https://www.3tu.nl/cee/en/events/cdio_conference/online-courselinear-modelling-shroff.pdf

Teachers were enthusiastic because:

1. They are ready for their thesis (master students, PhD students)
2. They become industry ready, this is because of the practical part of the course.
3. Improve the link between theory and practice

1 student dropped out (10%),

Main conclusion of teachers participating in this lecture was: **Blended and online learning is cool!**

Formative Assessment and Feedback

- Peer Feedback in Design (Tijn Borghuis)
- Using automatic and semi-automatic feedback (Lauri Malmi)

In the session on formative assessment and feedback, two contributions were presented, one from the Netherlands (Borghuis) and one from Finland (Malmi). Both men presented on how they handled feedback and assessment in courses with large groups of participating students (700-2000 students), with a diverse student audience, and with repeated assessment moments. The contributions presented solutions to cope with these requirements. Borghuis told about experiences with a system (peach) that can help teachers to group students for assignments with peer feedback. In his course, students had to complete assignments as well as provide feedback on assignments of other students, and both assignments themselves as well as contributions were graded or part of course grading. It appeared that peer feedback is feasible and enhances student learning and performance, yet there are several caveats to take into account. Some of these include students providing feedback just for the sake of having assignments completed, the fact that students not always accept feedback from their peers, and the fact that systems need to take into account reasons of students for not providing feedback on their peers (system errors, forgetting to do so, or other reasons). Malmi told about software and systems to help teachers to provide more automated feedback where this is possible. Such opportunities present themselves with assignments that are clearly structured, or that have a certain logic. Also, given the repeated nature of student misconceptions or errors, some

feedback can be created automatically, whereas as teacher you want to provide personal feedback where this is relevant; automated systems can help to do so, or can provide feedback statements that with little effort can be tailored to specific cases.

The audience recognized many of the challenges and issues associated with peer feedback and formative assessment, but liked the suggestions put forward by the contributors, both in terms of design criteria for setting up feedback, as well as in terms of software, websites and other tools that apparently are available to help teachers in providing feedback in large scale courses!

Improve teaching by learning from critical colleagues

Jens Bennedsen

The workshop on the evaluation of engineering programmes addressed the question on what it is people actually mean when they say the engineering programme is of high quality.

By discussing the interpretation of criteria on "student feedback", "use of technology", "work field involvement" on different level of quality assurance ranging from a need, plan, implementation, evaluation to the highest level stakeholder involvement we calibrated what this terminology actually implied and how then our own institutions would rank on this different level with respect to that criterion. It challenged us to discuss our assumptions about what we commonly understand with these educational terms and share best practices/ ideas of excellent approaches to realise the consolidation of quality enhancing activities.

Participants particularly appreciated the applicability of the criteria, hands on implementation session of these criteria and the variety of experiences of the attending partner universities in Europe. They felt equipped to make the next step in their own departments and taking home the good news of being on the right track.

Maths and Engineering: Blended Learning

- Best practice of blended learning in Calculus Hans Cuypers

At the TU/e, student enrolment has gone up. This year, 2248 1st year students enrolled for one of the TU/e programmes. The challenge is to give calculus to all 1st year students and still make it challenging and motivating for all of them. Also the pass rate needed to go up (from 50% to 70%). To achieve this, calculus was redesigned into a blended approach. Design principles:

- Students work actively from day 1
- Where and whenever they want
- In cooperation with fellow students
- Receiving personalised feedback
- Getting awarded for their work (credits)

Like in Delft, there is a cycle that is repeated throughout the course. This cycle consists of four parts:
1) Introduction – 2) Practice – 3) Discussion – 4) Test
In every part the students receives individual feedback.
This approach does not replace lectures. Students still receive 6 hours a week of lecturing in a large lecture hall. Homework assignments have to be handed in every week. Randomly, some exercises are chosen to be assessed and commented on. There is also online homework with custom feedback given to students. Results are registered. Every week students have a one-hour meeting with a tutor in which students take

the lead. They ask each other questions about the assignments that have to be made. The tutor only leads the discussion and gives feedback.

Formative tests (3x) are rewarded with 10% of the final grade. At the end of the course students do a summative exam for which the student has to obtain at least a 5.0.
Students receive an overview of scores on the formative tests compared to the average score of fellow students so they can see how they are doing.

Results are a higher pass rate and appreciation of students (good evaluation scores).
Students appreciate the new setup because it is a clear system and they know what to do.

MyMathLab and Mastering Jan Willem Polderman

At the University of Twente, MyLabsPlus is used for diagnostic testing in 1st year math courses (± 900 students). Students can do one test a week and every test contains 6 to 9 randomised problems. The tests have to be made within a time frame of 30 minutes.
Goal of using these tests is stimulating students to spread the workload over the entire module and enhance student motivation.
A disadvantage of the test is that you can only see the answer the student gives, not the steps leading to this answer. If the answer isn't correct the students do not get any points for the approach (on the other hand students do learn to be precise and look at their answers critically).
The math teacher from the TU Delft also faced this problem but solved this by allowing an error margin of 3 to 5%. Also, students can do more than one attempt. At the TU/e students can do as many attempts as they want but they get different parameters each time. Also, a limited time frame isn't used.
The audience is asked to solve a math problem which proves to be quite hard for most people. A question from the audience is: isn't it better to ask the type of questions that are easy to answer once you understand what to do? The presenter partly agrees, but adds that MyLabsPlus has a 'simple calculator' that can be included in an assignment that makes it somewhat easier for students to calculate the answer.

- Towards combined learning analytics for improving CDIO curricula Ewoud de Kok

In his presentation Ewoud de Kok focused on software to motivate students during lectures in an interactive way. During lectures, students can answer to multiple choice questions or answer to open questions or send in questions themselves. A plugin for Blackboard is available. URL: https://secure.feedbackfruits.com/
For more information about this software contact: Ewoud de Kok: ewoud@feedbackfruits.com

Maths and Engineering: Making the connection

- Simulations-based mathematics in Mechanical Engineering Mikael Enelund

At Chalmers math education was reformed since 2006 – 2007 and combined with programming education to what they call 'simulation driven design'.
The reason for this reform is that an increasing number of students will work with computations and calculations after graduation. Solving most problems faced in modern engineering includes high precision digital models and solutions. The programme has to prepare them for a modern approach. Also, students need to see the connection between the designs they make and the math that is taught to them.
The reformed math education includes a basic course in matlab programming. Also the focus shifted from solving oversimplified problems with known solutions to more open general problems. In other engineering courses math is integrated so students see the application of the subject.
Students write their own algorithms and write their own programmes based on a problem description, gaining both programming skills as well as insight in math. For programming, matlab is used, but students are also allowed to use something else (e.g. Python) if they prefer to do so.
Some courses have joint computer assignments, for example Statics and Linear algebra have a joint assignment about stress analysis of a plane elastic plate.
Finite elements is already introduced in the 1st year and applied in the Solid mechanics course.
As a result, students are more motivated for the math courses and gain more knowledge and skills (programming, decision making, etc.). Math lecturers at Chalmers are not very happy with the new approach though because they prefer teaching math in the traditional way.

- Project-based Maths at DTU Karsten Schmidt

Mathematic skills and attitude towards math are very different amongst 1st year students. How can we motivate them all? Karsten talks about two approaches to teaching:

1. Ordinary approach. Lectures, exercises, etc.
2. Project based approach
   - Small thematic problems based on the discipline (e.g. cell division or river deltas)
   - Large project assignment combining different subjects in something similar to a research assignment. Students are introduced in the subject step by step and then continue on their own. Examples of assignments are flow of groundwater and solar energy absorption in glass houses. Students work for 4 weeks (16 hrs. a week) on the project. At the end students deliver a project report.
     There is a portfolio of containing more than 50 project exercises from which students can choose. Students are very enthusiastic about this approach.

- Innovation of 1st year Mathematics at TU Delft Ingrid Vos

At the TU Delft there are ± 3000 1st year students all having to learn the basic math skills. Math is taught by math teachers. To innovate the math education, a project was done with 8 math teachers and an e-learning developer. Goals of this innovation were: efficiency, following didactic developments and stimulating study success.
Every quarter, a pilot was done at a different programme (a.o. Civil Engineering Electrical Engineering and Aerospace Engineering participated).
Design principles:

1. Students should remain active at all times

2. Context: know how it's used in your own programme or discipline
3. Feedback
4. Conceptual understanding

Blended learning cycle:
Self-study at home using short pre-lecture videos (± 7 minutes) in which concepts are explained. Then a face to face lecture that starts with a quiz (to make a connection between the pre-lecture and the lecture), followed by explanation of new concepts and problem solving (individually and in small groups). At home students continue working on the subjects with exercises (computer and book).
The computer exercises that are used are a combination assignment offered by Pearson and self-made applets. There is also a pre-university calculus course offered fully online as a MOOC.
Materials can be used free of charge and can be found at: http://math-explained.tudelft.nl

Multi- and Interdisciplinary Engineering Education

- Literature review and framework A. van den Beemt & A. van de Ven)
- Interdisciplinary education in Built Environment Marco Lub
- Technical Medicine Group S. van Baalen & M. Boon
- Next Generation Robots Chris Verhoeven

The multi-interdisciplinary workshop conducted by the 3TU Centre for Engineering Education had 3 case studies. One on Clinical Technology, one on Robotics and finally one case in Urban development. Each case was discussed in a subgroup. In the Urban Development group the key to learning was through experiencing the influence of working in a multi-disciplinary group on a joint assignment. We approached this question by means of Lego Serious Play; building with Lego – thinking with your hands to come up with new solutions. The take home; Make your assignment open, but show what the results should be in terms of deliverable format. Avoid any priming effects that limit the creative input. Do not try to force regulations on a process, it limits the effectiveness and play and experimental aspects.

A more broad result was that team-members should be carefully selected as to what they might contribute, contrary to the previous findings. Working methods are key to the desired process and results taking place within the multi-disciplinary setting.

New Learning Environments in Engineering Education

Michiel Schuurman & Gillian Saunders-Smits
In this workshop the participants experimented with forensic engineering. In groups they needed to solve the case of the cracked eggs by interpreting data (from photographs and sensors) of ' eggcidents' in which eggs where dropped form a height. Forensic engineering is taught to teach students logical and critical thinking and work together in a team and to show them that life is not like on television. The course consists of both theory and practice. Learning objectives are:

- Describing and explaining the accident investigation goal and identify and analyse the different investigation phases.
- Demonstrating and applying accident investigation techniques.
- Selecting and using forensic investigation techniques to determine failure causes.
- Having knowledge of constructing and testing hypothesis and the ability to go through a verification process.
- Writing an Annex 13 accident report with fact, analyses and conclusion including the formulation of recommendations

Online Playground

Gillian Saunders

In this workshop participants were able to play with several online tools (Edge, Video Scribe, Making Cartoons, Editing and recording videos) and a trip to the DIY-studio was made. With every tool, there was an expert to explain the tool, and you could try it directly, which was very appealing. We made a video scribe in a few minutes, made our own cartoon and did some recordings in the studio.

The effect of this workshop was that participants experienced that blended learning indeed can be very cool. It is an engineering experience and if you give engineers a tool, they want to figure out how it works!

Redesigning Engineering Curricula

Maartje van den Boogaard

Maartje van den Boogaard (TU Delft) and Henk Schellen (TU/e) gave a very interactive workshop about redesigning a bachelor engineering programme.
A case was presented of the fictitious bachelor programme 'Water Design and Engineering'. The programme is in trouble and threatened with closure if student enrolments do not improve. Also study rates need to go up.

The problem is that the programme consists of too many small courses causing high workload for students (and staff). Also, there is a division in the teaching team between the water designers and the engineers. Student appreciation is going down. Enrolment is decreasing.
There is a group of older staff members that is reluctant to change.
The audience is asked to take up the role of educational consultants and work on an advice in a team.

The teams work enthusiastically for about half an hour and come up with different ideas:

- Thematic project education
- Internationalisation of the programme to attract more students
- Programme branding, new title
- Career development based on teaching quality
- Involvement of staff (and students) from the start
- Large change needs a strong cause and strong support from those involved

After presenting the ideas to the audience, the workshop leaders give some explanation from the project they did for the Centre of Engineering Education (CEE).
To find out what aspects were considered during the bachelor innovations at the University of Twente, TU Delft and TU Eindhoven, interviews were held with people involved in the bachelor innovations at electrical engineering and architecture at all three institutions. Interviews showed that conversations were often addressing content and branding, but lots of other important aspects (support base, involving students and staff, etc.) were not mentioned.

Based on these interviews and literature, a heuristic was made including all aspects to take into account when engaging in a curriculum innovation. The heuristic is available on the 3TU.CEE website. The full report of the project is almost finished and will also be made available on the site:
https://www.3tu.nl/cee/en/publications

Remote and Virtual Labs in Engineering Education

- Towards Virtual Labs (Lisa Jansen)

Lisa Jansen (TU Delft) wrote her thesis on virtual and remote labs. Virtual labs offer educational institutions advantages in terms of capacity, costs and flexibility in time. But are virtual labs also an educational improvement? Do they help students to learn better?
Different types of labs are compared (conventional, remote, 2D and 3D).

The advantage of a conventional lab is having face to face contact with the lecturer and fellow students. Also, a student practices the skill as needed in real life including the use of all senses (e.g. use of smell when doing chemical experiments). Virtual labs have the advantage of safety and access to unique labs over the world. Also things that cannot be seen with the bare eye can be made visible (e.g. air flow).
All types of labs also have their disadvantages.

When implementing virtual labs, attention must be paid to:

- Supervision and feedback
- Need for interaction with lecturer and fellow students
- Personalisation, adaptation to individual student needs

The next step is virtual reality and the use of holograms for educational applications. Microsoft is working on HoloLens (https://www.microsoft.com/microsoft-hololens/en-us) which might offer possibilities for an improved virtual lab experience.

- Go-Lab Project (Ton de Jong)

Ton de Jong (UT) talks about the GO-Lab project focussing on instructionally embedded online labs for STEM education. Starting point for his project is the need for engaging education in Science, Technology, Engineering and Math to interest young children. Industry asks for more graduates in the STEM programmes. Part of the solution could be in to include it in earlier education.

At meta-analysis from Freeman et al (2014) concludes that active learning increases student performance in science, engineering, and mathematics. The GO-Lab project focused on one specific type of active learning: inquiry learning with online labs.

Several examples of virtual experiments are shown. Active learning is proven to be effective, but is this also true for online laboratories? The answer is yes, provided that they are well designed and good structure and supervision are offered.

A large repository including more than 250 virtual labs was made: http://www.golabz.eu. The GO-Labs repository also offers a set of apps; small web based software applications supporting specific learning or teaching goals and tasks in online labs. Examples are a concept mapping tool and an experiment design app.