Do it and learn - Educating engineers at DTU Mechanical Engineering

By Lisbeth Lassen

Education is a highly prioritised area at the department, and during last year, several initiatives have been taken to develop the competences of the lecturers at DTU Mechanical Engineering.

Associate Professor Claus Thorp Hansen is pedagogical coordinator, and he coordinates activities between the department and LearningLab DTU, a centre offering pedagogical training at the university. He has been pedagogical coordinator since 2012, and in cooperation with LearningLab DTU he has developed and is co-responsible for the UP education (University Pedagogy for Experienced Teachers).

"This summer we held a department seminar in order to educate more pedagogical supervisors at the department," Claus Thorp Hansen tells. A pedagogical supervisor is assigned to every new teacher when they enroll in UDTU (Education in University Teaching at DTU) in order to qualify their teaching. "At our seminar, we spent half a day discussing what kinds of profiles we would like the graduates from the different Master's programmes to have. And for the first time, all sections but one has a pedagogical supervisor, so now it's possible for a new teacher at any section to have a supervisor with a different scientific focus. This way we avoid the temptation of discussing our research, and not our teaching."

Claus Thorp Hansen describes good teaching today: "For teaching to be excellent, it is fundamental to be aware that the more we lecture as teachers, the less active the students are. Learning happens when you are working actively with a subject, and if the students just sit in an auditorium and passively listen and maybe even lose concentration, they will not achieve much. The essence of excellent teaching is to create learning situations where the students are working actively with the subject, and where the purpose and application is clear."

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Updating and qualifying our skills and competences in teaching is important, as students today often have very different learning preferences or strategies than we, their lecturers, had when we were students years ago. So pedagogical strategies need to change and expand focus, and this is part of the course content in the UDTU and UP programmes.

The power of a relevant case

Activating the students is already part of the teaching in many courses at DTU. Professor Tim McAloone, Lecturer of the Year 2017, uses cases and examples of problems as an integrated part of his teaching. He is course responsible for the Master's course "Development and operation of product/service-systems" and the Bachelor courses "Product life and environmental issues" and "Sustainability in engineering solutions".

"I use examples the students can relate to, simply to start them thinking," Tim McAloone says. "I have many years of experience with using cases, which also includes some bad experiences of using case examples that are too complex for the students to understand – and this is not the way to do it. One needs to find examples where the

Students from Professor Tim McAloone's courses often take their business ideas to innovation competitions. Here Natasha Fiig and Kathrine Hagen have just won the 1st prize in the Green Challenge in the category Bachelor final project for their project "Roof Tiles from Thin Plastic Waste in India". MP Mogens Lykketoft is presenting the award of DKK 30,000. Photo: Mikal Schlosser

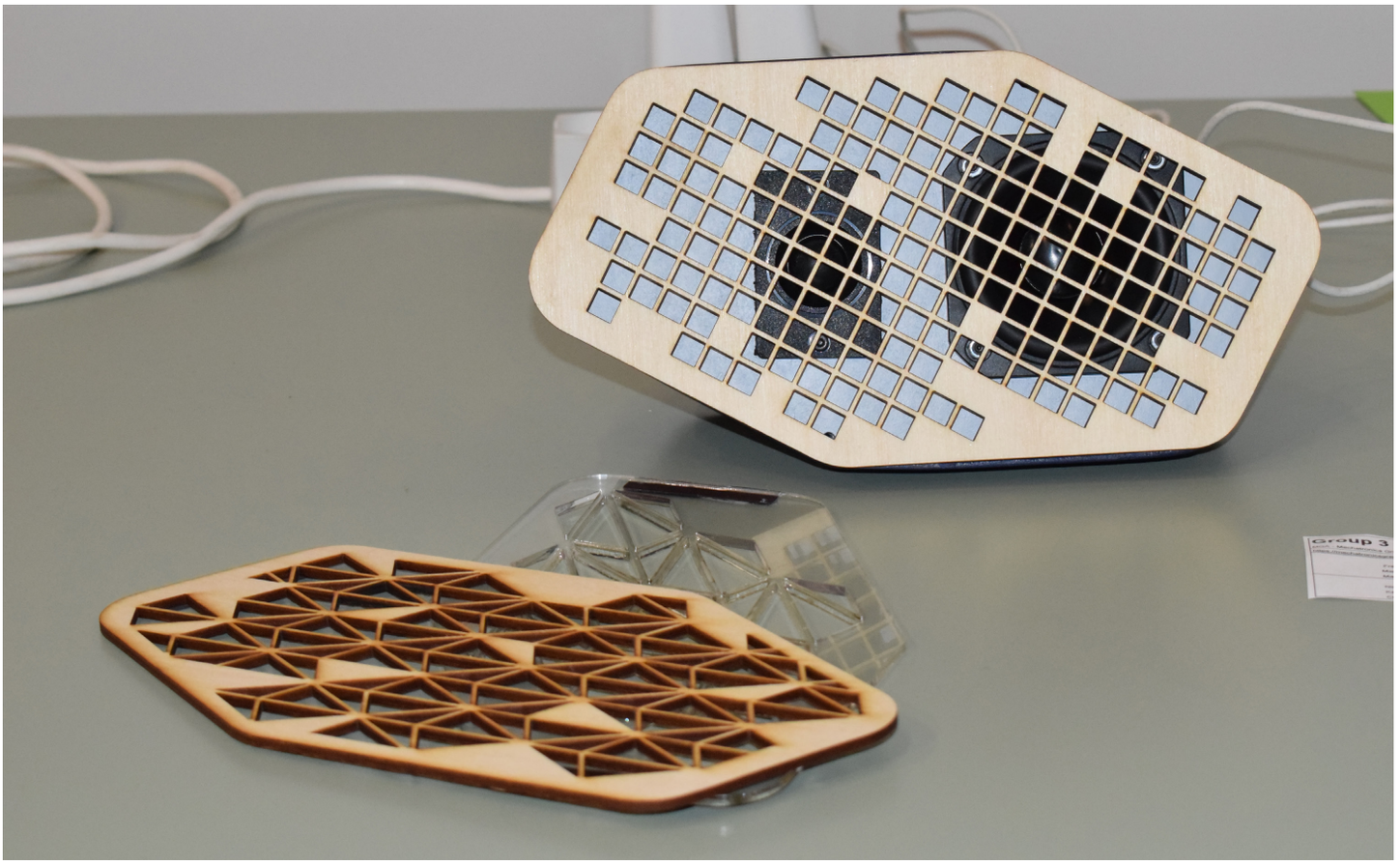
students can focus on exactly the point or the issue that one wants them to understand, and for this reason I often begin by bringing many everyday products as examples, like tuna cans, milk cartons, children's shoes or bicycle lights."

The students are then asked to consider design and environmental issues related to the different products that I present to them. Slowly but surely – as the students' understanding at the theory develops, the case examples get more complex too.

"All our courses are about designing better and more environmentally considerate products and systems, while also considering economical and business aspects," he continues. "In the design phase, engineers should consider all life phases of a product: Raw materials, production, transport, use and finally end-of-use. We train the students to think of all the possibilities and necessary considerations in every single life cycle phase. The basic idea is to make them think holistically and methodically at first, and then we can raise the level of difficulty when they grasp the basics."

In the Master's course "Development and operation of product/service-systems", Tim McAloone frequently spends the first day on letting his students produce orange juice by different means. In the experiment, the students are required to make juice using an electrical juicer or a hand-powered juicer, after being asked to consider which method is the most environmentally sound. "They all start by saying that the hand-powered juicers are the most environmentally beneficial. Then I give them 4 oranges each and 1 minute to produce as much juice as possible. The electrical juicer always produces the largest amount of juice. Afterwards, we discuss the exercise and reach the conclusion that a small portion of electricity for an electric juicer might just be worth saving the last drops of juice from an orange that has travelled thousands of kilometres in a truck to reach Denmark! This leads us to assessing the total costs and environmental loads of producing the juice, including the transport of oranges from Spain to Denmark. We can calculate how many megajoules the transportation takes, compared to the few megajoules it takes to produce considerably more juice by using the electrical juicer."

Is juice produced with a hand-powered juicer more environmental friendly than juice produced with an electrical juicer? The juice experiment is part of Tim McAloone's course "Development and operation of product/service-systems". Photo: Colourbox



A wireless, 3D printed loudspeaker made by a student team at the BSc course "Mechatronics Engineering Design". Bang & Olufsen supplied the hardware for the prototypes.

This hands-on case of different means of producing orange juice accelerates the students' understanding and analytical approach to subjects like life cycle thinking, product development, and sustainable innovation.

Professor Tim McAloone's use of cases and hands-on examples was highlighted as one of his key characteristics as a teacher by a number of students who nominated him for the award Lecturer of the Year 2017.

Mechatronics: from a conceptual course to hands-on prototyping

A number of courses at DTU Mechanical Engineering have undergone a transformation from lecturing to activating the students with hands on projects, among them the BSc course "Mechatronics Engineering Design". Associate Professor Ali Gürcan Özkil is course responsible and he describes this transformation: "The course was created because we needed the skills within the field of mechatronics in the curriculum, and we had to have a course that incorporates skills from a broad spectrum like electronics, software engineering, mechanics, design, and entrepreneurship. In the beginning, it was very conceptual and similar to other courses with classroom teaching and slides, but it soon evolved into being extremely hands-on and focused on prototypes."

The main focus of the course is still the same theory, but with assignments and the so called sprints which are short time projects for teams. The course is organized with four sprints during the whole course, so the structure is 4-5 weeks, and then one project, 4-5 weeks, then another project. The first project is more thematic and the last is combining the different subjects. All teams end up with a functioning prototype.

Ali Gürcan Özkil definitely sees great advantages in learning with hands-on design projects and prototyping for future engineers: "It's what we are looking for in the modern world: If you talk to people who hire students when they graduate, when you read academic papers, when you hear politicians talk, the theme is all about this. People who can actually do things; engineers who can engineer."

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According to the course leader, the ability to conceive and create prototypes is of great importance to engineers, and especially to design engineers or engineers who are going to contribute to industry. "We can see that prototyping is extremely important if you want to make a start-up, or if you want to work for a large company developing new products. Prototypes are where ideas make or break. If you can't prototype a nice design from the screen or from some calculations, it doesn't become anything. We are still living in the physical world, and that's why prototyping is so important in all engineering education, and especially in design engineering and mechanical engineering."

Basically the students learn to cross the gap from calculating something and drawing it on a screen, to creating a proof of concept that actually works according to the laws of physics and the limitations of manufacturing. Mechatronics is also a subject that forces each student into developing knowledge about a wide variety of disciplines from electronics, sensors, software, mechanics, design, and manufacturing. The students in the course come from different study lines, most of them are from Design and Innovation, but there are normally also students from Mechanical Engineering, Software Technology and even external students.

Engineers with Swiss-army knife profiles

The students are developing cross disciplinary skills when working with prototypes, and this has an important perspective for industry and society. This became very apparent to Ali Gürcan Özkil at the seminar "Mechatronics in engineering education", which was held this summer:

"We hosted a seminar in mechatronics in June, and the feedback we received from the industrial participants was that what we need are engineers who can pick up the problems and come with solutions right after their graduation. This is especially important in Denmark where the economy is driven by small to medium sized companies that don't have the strength and the power of very large companies. For small

companies, it is a luxury to just have one engineer who does one single job; they need people who are like Swiss army knives and who can at least learn what to do when facing problems. The problems they experience can't be put in boxes as just a mechanical problem, a software problem or an electrical problem, often it's a combination of these things in real life," he says.

The cross disciplinary approach that the students learn by working hands-on with prototypes is a very relevant approach in relation to digitalization and the development of smart or intelligent products.

"So our course gives the students a real perspective on what is happening in industry and in society. Some of my former students are now hired in companies, where they face the same problems. Hearing aids, for example, are not a mechanical or an electronical product anymore, and they connect to the internet and communicate with other devices. Even conservative companies are considering how they can make their products smarter. We need to act on this development," concludes Ali Gürcan Özkil.

Presentation of the new prototypes, 3D printed wireless speakers, manufactured by the students in the BSc course "Mechatronics Engineering Design", where Associate Professor Ali Gürcan Özkil is course responsible.

See examples of prototypes from the course Mechatronics Engineering Design: