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*Publication date:*  
2011

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*Citation (APA):*

Skov, A. L., & Kiil, S. (2011). *Teaching chemical product design to engineering students: course contents and challenges*. Abstract from 7th International CDIO Conference, Copenhagen, Denmark.

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# Teaching chemical product design to engineering students: course contents and challenges

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## **ABSTRACT**

Chemical product design is not taught in the same way as traditional engineering courses like unit operations or transport phenomena. This paper gives an overview of the challenges that we, as teachers, have faced when teaching chemical product design to engineering students. Specific course contents and relevant teaching methods are discussed.

## **Introduction**

The master course Chemical and Biochemical Product Design has been taught to engineering students at DTU for the past 10 years. The course covers the main phases of product design from mapping of customer needs, over idea generation and selection, to product development. Details of this approach are available in text books on the topic [1,2]. The primary aim of the course is to provide the students with a quantitative approach that enables them to analyse products and ideas using fundamental scientific disciplines from the engineering curriculum. The course is comprised of four team projects of which the last one (60% of the work load) is dedicated to the student teams own identified needs. Examples of needs that students have worked on are solvent-free nail polish, fast cleaning of baby bottles, new ways to anti-icing on cars, slow-melting ice cream, and coffee tablets for instant coffee.

## **Results and discussion**

Some of the main challenges in teaching the course are team work in teacher-selected groups, very open-ended problems, lack of relevant data for detailed design work, and different cultures working together (about 50 % of the students are non-Danish). These issues will now be discussed in more detail.

### Team work in teacher-selected groups

From the very beginning, it has been an aim of the course to teach the students how to work in teams of people with different professional and personal backgrounds. The purpose is to simulate a real working environment. About half of the students take this as an interesting challenge. The other half of the students is not comfortable and the main concerns are about relying on group performance rather than the individual performance as in most other courses

within our department. We use a simple personality test with four groupings in the process of putting the teams together. We put priority to having one of each personality type in each group but also prioritizes that all groups have a similar ratio of Danish to foreign students to enhance the interplay between students with different cultural and educational backgrounds.

During the semester we monitor the team work by having the students fill in a “narrative“, where they evaluate their own and the other team members efforts. This allows the teachers to take action if one or more students are not participating actively or the teams are simply not getting on. Usually the problems arising are due to either poor English skills (as the course is taught in English) which limits the capability of the student to participate actively in the group work or are due to free-riders who will not show up for the scheduled group meetings or will show up unprepared. We haven’t solved the language problems but we hope that the screening of the prospective foreign students will become more efficient in the future. With respect to free-riders we require that the team during the first week of the course formulate, agree on and sign a team contract on how they want to the project team to work together. The contract is handed in to the teachers as well and allows first of all the students to confront each other and ask for improvement according to the contract. However, the problem with free-riders usually ends up at the desk of the teachers after the hand-in of the first project or after the narrative procedure (usually after the first two projects). We then arrange meetings with both the free-rider but also with the remainder of the group to identify with is the core of the problem. In most circumstances, we end up with constructive conversations and we observe a clear improvement of the working habits of the free-rider but we also observe that the group usually works hard on including the free-rider in order to optimize the performance of the group.

In recent years, we have used teacher-selected groups in the first part of the course and student-selected groups in the final project. Both teachers and students are generally satisfied with this arrangement, though some students still feel that they should not be forced into groups with people they do not know and share grades with them.

#### Open-ended problems

In the final large project, the student teams must come up with a need by themselves and bring that need from a market analysis to a final product idea and describe a production of that particular product. During the project period we, as teachers, behave as mentors and try only to catalyze the process. Overall this works very well for most teams and so far all teams have managed to identify a relevant need. At the end of the course, the teams present their project to the other teams and there is an individual oral examination on the project report.

#### Lack of relevant data for detailed design work

Specifying product needs and detailed production planning are serious challenges. This is because it is difficult and time consuming to find relevant data

to use for detailed calculations (cost, equipment). In recent years, we have only gone to the level of setting up flow sheets in the case of production. This seems to be an acceptable way of handling this part.

### Cultural differences

About 50 % of the students are non-Danish. This means that working habits and planning of projects are approached in different cultural styles. This can cause some frustration in the teams and we therefore spend some time the first day to explain the “rules of the game” and we let the student teams put together a contract as mentioned earlier stating how they have agreed to conduct the team work. All team members sign the contract. This has worked out quite well.

### **Conclusions**

Based on more than 10 years of experience, we conclude that it is possible to teach product design to engineering students, but many students prefer well-defined and concrete assignments. However, it is essential also to educate engineering students to handle design problems and understand the customers using the products they produce. In future years, an increasing number of chemical engineers will be working on structured products.

### **References**

- [1] Wesselingh, J.A., Kiil, S., Vigild, M.E. Design and development of biological, chemical, food and pharmaceutical products, Wiley, 2007.
- [2] Cussler, E., Moggridge, G. Chemical product design, Cambridge University Press, 2001.

*Relevance* – The CDIO principle is practised in the course through customer interviews, idea brain storming, selection of ideas, simple experiments, and setting up a production of a relevant product.

*Submission Category* - paper presentation.

*Keywords* – design, products, production, innovation