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Collaboration between courses in the interdisciplinary course Food Microbiology

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ABSTRACT

Food Microbiology is an interdisciplinary 12.5 ETCS second-year) course in a CDIO-based Bachelor of Engineering program in Food Science at The Technical University of Denmark (DTU). The course was first offered in 2011. Each session in the Food Microbiology course combines theory and practice in order to strengthen the students' application-oriented competences and engagement. In this paper the results from the evaluation of the course will be presented and a discussion will be carried out about how the students responded to the multidisciplinary, real-life projects and how it affects student learning.

The aims of this study were to test 1) the students' perception combining theory with small laboratory exercises and 2) the students' perception of how the course collaborates with and combines theories and practices from other current semester courses. The students evaluated the course in general using the Course Experience Questionnaire (Ramsden, 1991) and by answering a questionnaire concerning the collaboration between the other courses.

It can be concluded that the combination of: theory/laboratory exercises/report writing stimulated the students' motivation and that collaboration between other mandatory semester courses mainly was rated positively by the students.

KEYWORDS

Interdisciplinary, collaboration, motivation, evaluation
CDIO Standards: 6 and 8

INTRODUCTION

Besides gaining a basic microbial knowledge about relevant food bacteria, one of the main teaching strategies in this Food Microbiology course is to include real engineering problems. Each session in the Food Microbiology course consists of a theoretical part which is supported by corresponding laboratory exercises. The main idea behind the design of the course is that the combination of theory and practice strengthens the students' application-oriented competences and that the variation of work will maintain their engagement.

By using these main principles in the course design it is also likely that the students will enhance their disciplinary knowledge. Through applying the theoretical content of the course to practical applications, the students are given the possibility to understand the theory through their own active experimentation. Likewise, this gives them a concrete mental experience of the connection between theory and practice which makes the construction of their knowledge much more accessible (Kolb, 1984).

To be able to intrinsically motivate the students in a course is one of the most important things (Ryan & Deci, 2000). Through a setting where the students actively work with elaborate problems and through the use of authentic learning using real engineering problems, the students are more likely to become intrinsically motivated (Pascual & Andersson, 2012). Active students and intrinsic motivation are also important components to support the students to adopt the preferably deep approach to learning in the course which supports their construction of knowledge and retention of knowledge (Marton & Booth, 1997).

A deep approach to learning thereby also helps the students to, in a more effective way, recall what is learned and to use it in new and different contexts, which is crucial for them in order to develop to become skilled engineers working on complex problems. Those ideas about how learning is enhanced are also embedded in the teaching and learning principles in CDIO and show the usefulness of working in accordance to CDIO in Engineering Education in order to support the students' development of engineering knowledge and competences during their education (Crawly et al., 2007).

In this paper the course design that followed the CDIO principles is described. The Course Experience Questionnaire (CEQ) (Ramsden, 1991) that was used to evaluate the students' learning experience is presented as well. By using the CEQ, the students' specific experiences of the teaching methods' impact on their deep approach to learning and their motivation can be highlighted. If the students perceive the course design as good to support their learning and experience, then they are motivated during the course and most likely they will learn the course content in an effective way.

Course construction

The course consists of 13 4-hour sessions followed by a 3-week, 7 hours a day period. The 13 sessions consist of theory with matching laboratory exercises. Three subjects from these sessions were selected for report writing. The 3-week period is an exam where individual students are given exam problems. In this period they have to use their gained theoretical knowledge and laboratory experience to solve the problems. They have to write two small reports and the course ends with individual oral exams.

The course focuses on bacteria related to foods and can be categorized by 1) foodborne pathogens, 2) bacteria that are used to ferment foods and 3) bacteria that can spoil the food. The most important core element in the course is pathogen bacteria and is therefore the main subject in 6 out of 13 of the 4-hour sessions. Fermentation and lactic acid bacteria are the secondary core elements.

The overall intent of the course is to develop the students' competences so that they can identify, characterize and work with bacteria in different aspects, giving them practical skills so they can handle the bacteria in the laboratory and use their knowledge in the industrial world.

Incorporation of real engineering work-related examples in the teaching

To draw some parallels to real engineering work, the students learn to detect and identify bacteria by using classic microbial and molecular methods that are used in the industry or control laboratories.

Another example related to engineering tasks is fermentation of foods. First, the students learn about growth and metabolism of lactic acid bacteria and how it can be used for fermented foods. Then, in another session, the students learn about and work with bacteria virus (bacteriophages), and how it can infect and kill bacteria. Bacteriophages correspond to human viruses – they can only infect bacteria. In a third session, the students try to ferment milk to produce sour cream using the same strains and methods as used in the dairy industry.

One engineering problem that the dairy industry constantly struggles with is that lactic acid bacteria can be attacked by bacteriophages during the fermentation process. Bacteriophages are everywhere and are difficult to get rid of. If bacteriophages invade the lactic acid bacteria cells they will be killed and this results in fermentation failure and a destroyed product. To illustrate this problematic fermentation, the students try to ferment sour cream in the laboratory where bacteriophages are added to one fermentation batch so they can experience how it affects the product. During the fermentation the students enumerate the number of bacteria simultaneously with measuring the pH and they can experience how a failure of fermentation can affect the product.

Through this combination of knowledge and practical work, the students face real problems they could face in the dairy industry. Including real-life engineering cases is a method to motivate the students and thereby increase their learning in a course.

COLLABORATION WITH OTHER SEMESTER COURSES

To upgrade the real complex engineering problems, collaboration between the other third semester courses was established and interdisciplinary projects were created with Statistics, Analytical Chemistry and Food Production courses. Since Food Microbiology is a recently offered course, it is flexible for changes and adjustments. This was a good opportunity to implement the CDIO principles in teaching practices.

Collaboration between Statistics and Food Microbiology

The students tested two different plating methods for enumeration of the pathogen bacteria *Salmonella*. All the generated data for all the groups were collected and used for statistical analysis. In the Statistics course, the students tested if there were statistical differences between the two methods. In addition, the students wrote a microbial and statistical report.

Collaboration between Analytical Chemistry and Food Microbiology

The students identified and characterized food-related molds in the laboratory. Samples were taken from selected molds and chemically analyzed for toxin production by High Performance liquid chromatography (HPLC). The HPLC data were computer analyzed by the students in an Analytical Chemistry session.

Collaboration with Food Production and Food Microbiology

In the Food Production session, fish from a fish farm were caught and the students sliced and vacuum packed the fish. After storage, the students analyzed the fish in Food Microbiology for natural flora and pathogens.

In the above-mentioned projects, the students face more realistic complex problems where they have to combine their knowledge from the other courses just like they will have to do as professional engineers in the food industry.

EVALUATION STRATEGIES

Student evaluations are a useful tool to adjust teaching (curriculum and methodology). The first time the Food Microbiology course was conducted the students' continuous evaluation was used as a tool to adjust the sessions throughout the semester. Because it was the first time the course was offered, adjustments were necessary due to the fact that teaching theory took longer than planned, which resulted in less laboratory time.

The course has been offered two times and is still being evaluated systematically to continuously improve the course. The second time the course was offered, every other session all students answered an evaluation note with two questions: 1) what is working well and 2) what is not working well. In the alternate sessions, there was a small conversation with two students about how the course was going with regards to collaboration with the other courses.

The second time the course was offered, a more detailed Course Experience Questionnaire (CEQ) was used to evaluate the course. Even though we received feedback from the students, the lecture plan was followed and no adjustments during the semester were made.

Course Experience Questionnaire evaluation on the course in general

By using a CEQ the students evaluated the Food Microbiology course in general. In total there were 22 questions. The students were asked to mark the number next to each statement that most accurately reflected their view where 5 meant that they definitely agree, 4 meant that they agree, but with reservations, 3 meant that they are neutral, 2 meant that they tend to disagree, and 1 meant that they definitely disagree. The different questions were categorized into five different categories: Good Teaching Scale (GTS), Clear Goals and Standards Scale (CGS), Appropriate Workload Scale (AWS), Generic Skills Scale (GSS) and Motivation Scale (MS) and the average score was calculated. The higher the score, the more positive perception – except for AWS; that should be close to 3 to be considered as most positive (Figure 1).

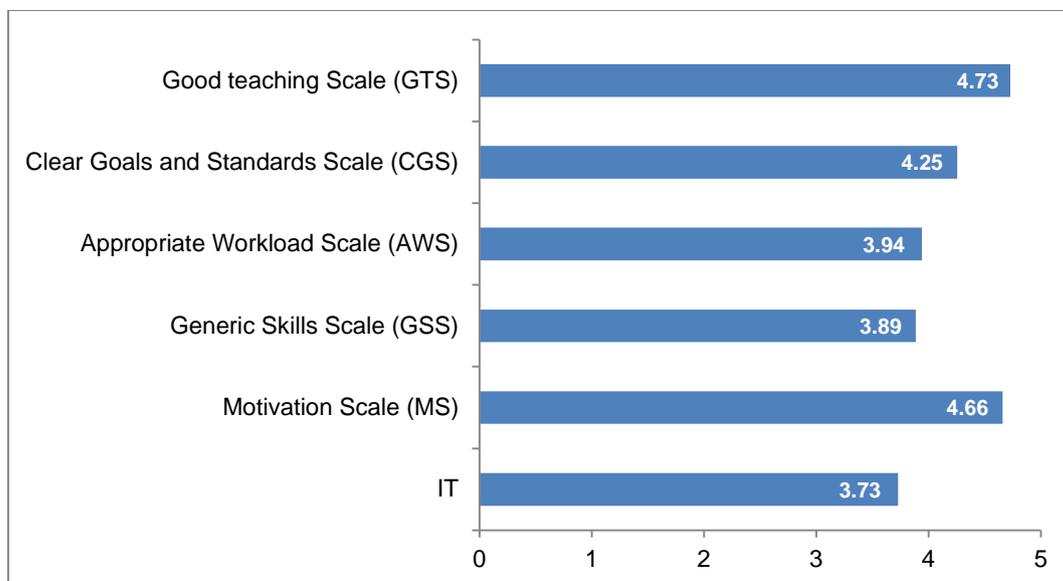


Figure 1. Results of scoring from the CEQ with a response rate of 85%.

The average scores for three of the categories are above 4, which is quite positive: GTS (4.73), CGS (4.25) and MS (4.66). The two categories, GTS that measures the teachers' ability to contribute to student learning and MS that contains stimulation and motivation elements, are rated very positive by the students.

These ratings indicate that the teaching method: theory/laboratory exercises/report writing is a motivating form of teaching.

Evaluation of the collaboration between other semester courses

The evaluation questionnaire for the collaboration between the other semester courses included two questions for each course: 1) what worked well and 2) what did not work well. The questions were divided into a positive perception and a negative perception (Table 1).

The results from the evaluation questionnaire show that there are different perceptions of how well the collaboration between the other semester courses and Food Microbiology course worked.

Some of the challenges we faced due to the collaboration with the other mandatory courses was that the students were not taking all of the same courses. For example not all of the students had Statistics. In these cases, the students either went to that particular Statistics session that they needed to solve the statistical problem or they gave an objective assessment of the data. However, all the students that had the Statistics course in collaboration with the Food Microbiology course rated the collaboration positively. One of the reasons was that the students could relate to the microbial data that they had generated instead of the tasks in the textbook.

Table 1. Evaluation of the collaboration between the other semester courses and Food Microbiology. The two questions were given: 1) what worked well and 2) what did not work well.

	Positive feedback (%)	Negative feedback (%)	Neutral* (%)
Statistics	70		30
Analytical Chemistry	100		
Food Production	40	60	

* Students that did not follow the course

Collaboration with Analytical Chemistry was also positively rated by the students. The subject the students were working with in Analytical Chemistry has been used in other courses and therefore was well planned and integrated. One of the reasons that the students liked the course was that they were allowed to take mold samples from their own home and tried to identify the samples in the laboratory. However, the students found analyzing the toxins from the molds as challenging.

There were more opinions about collaboration with the last course, Food Production. Some of the reasons why there was negative feedback were because students felt it was unstructured and not well prepared. The Food Production course is also a new course and maybe that is why the teaching was perceived as unstructured by the students.

Some of the general problems with collaboration with the other courses were communication between the teachers, planning and decisions about relevant tasks. The courses Analytical Chemistry and Food Production are also new, and integrating new courses is always time consuming and therefore it might be difficult to establish collaboration between other courses.

Comparison of the two evaluations

Overall, the CEQ evaluation of the Food Microbiology course was rated quite positive, and besides the one course (Food Production), the collaboration between courses was also rated positively. Adjustments between collaboration with Food Production are needed for the next semester.

CONCLUSIONS

As the results from the CEQ indicate, students in the course are highly motivated and experience the teaching as helpful in their learning process. This minor but systematic investigation using CEQ shows that the underlying pedagogical principles in CDIO fulfil the assumptions with CDIO as a strong learning paradigm in Engineering Education. The key factor for success with a CDIO design in an Engineering Education is the design-build experience and to really take it to the level where deep authentic learning is used in the form of real-life problems or challenges from industry that the students can understand and learn from. The importance of this and the motivating factor is that the students can see what they will be working with and identify themselves as professional engineers. In this context, the content disciplinary learning in the course becomes much more meaningful and useful for the

students as they realise that without this knowledge they will not be able to handle their tasks as engineers in the food industry. Another important factor for success regarding motivating the students in this CDIO course design is that the students are activated and in charge of their own projects. They need to use their own knowledge in order to solve the problems they meet, and the teacher's role is to provide them with the right information in the subject and to supervise them in their work to transfer this information into knowledge.

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BIOGRAPHICAL INFORMATION

Tina Birk, Ph. D. is a lecturer in the Division of Food Microbiology at DTU and is teaching in the Food Microbiology course. She has been working with the foodborne pathogen *Campylobacter* in relation to survival in the food environment and stress response. Her current work focuses on antimicrobial resistant bacteria in the food production line.

Pernille Hammar Andersson, works as an educational consultant at LearningLab DTU at the Technical University of Denmark. She is coordinator and responsible for the teacher training programmes at DTU as well as other competency developing activities in teaching and learning. She works with projects aimed at develop teaching and learning at DTU departments and at DTU in general. She also works with deeper evaluation of new teaching methods and teaching and learning initiatives at DTU. On the national level in Denmark, she is a representative in the steering committee of IUPN, a national network supporting educational development in Danish Engineering Education and she is the vice chair of the Active Learning in Engineering Education network. Her academic background is in psychology and educational science.

Lars Bogø Jensen, Ph. D. is an Associate Professor in the Division of Food Microbiology at DTU and the Head of the study board at the National Food Institute and the Bachelor of Engineering Program in Food Analysis at DTU. His current research focuses on the identification of antimicrobial resistance and virulence determinants in bacteria.

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