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Re-design of the course "Dairy Processes and Equipment" with special focus on constructive alignment and evaluation of teaching

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Introduction

The design and structure of a course may have a major impact on the opportunities for students to obtain the learning intended for that course. Therefore, attention should be paid to this when introducing a new course; and a change in programme structure could be seen as a possibility for careful re-evaluation of existing courses and course elements.

The MSc education at University of Copenhagen in Food Science and Technology with specialization in Dairy Technology has in recent years included a 15 ECTS thematic course dealing with processes and equipment used in the dairy industry. While the relevance of the course is obvious to both students and teachers, and the course description outlines a fairly well aligned course, the student evaluations of the course performed on Absalon at the end of the course, have been relatively negative. There are several reasons for this, and some of these will be touched upon in more detail in this document, but the overall conclusion must be that improvements are needed. Furthermore, there has been an increased focus from both the university and the food/dairy industry, which should employ many of the students finishing the MSc education, on improvement and strengthening of the field of technology in the education. It has been decided that from the academic year 2013-14 the course will be split into two 7.5 ECTS courses covering Food Process Equipment in more generic terms and Dairy Processes and Equipment, respectively. The more generic course will be mandatory for more than one MSc specialization, thereby it is also hoped

to spend the teaching resources in the department more efficiently by minimizing teaching of more or less the same topics in different courses.

Constructive alignment is an example of outcomes-based design of teaching and learning. It was introduced by John Biggs in the 1990s and is based on a constructivist theory of learners needing to construct knowledge through own activities and the need for alignment between the intended outcomes and the way these are taught/learned and assessed (Biggs & Tang 2011). The intended learning outcomes (ILOs) should describe both what the students are supposed to learn as well as how it should be learned and at which level. This may be achieved by the use of verbs stating an activity rather than just a topic, and the choice of a specific verb indicates the level of understanding intended, e.g. based on the SOLO (Structure of the Observed Learning Outcome) taxonomy (Biggs & Tang 2011). Obviously, the ILOs should be designed so that the students are intended to reach an appropriate level of complexity in their understanding during the course. When the ILOs are in place, teaching/learning activities (TLAs) should be designed to match these, meaning that if the ILOs says "analyze" then the students should be trained in analyzing (the topic or data etc. in question) and not just watch the teacher doing it while taking notes. Finally, the assessment tasks (ATs) should assess the students on their level of performance with respect to the ILOs and using the competences obtained in the TLAs (Biggs & Tang 2011).

Aim of the project

The overall aim of the present project is to come up with a suggestion for structure and content of the re-designed course "Dairy Processes and Equipment" when this course is split from a 15 ECTS thematic course called "Dairy Processes and Equipment" into two 7.5 ECTS courses, called "Food Process Equipment" and "Dairy Processes and Equipment" (from here called DPE), respectively. Special attention will be paid to constructive alignment of the new course ensuring coherence between ILOs as described in the course catalogue, the TLAs, and the ATs. Furthermore, focus will be put on evaluation of teaching, both in the form of re-designing the ATs of the course and in learning from the student responses in their evaluations of the present course.

I have been involved in the teaching of this course for several years, but I am not the course responsible, and therefore, the present project can only be viewed as suggestions for the structure of the future course.

Methods and resources

The design of the new 7.5 ECTS course is based on the course descriptions for both the present 15 ECTS course and the new course. My personal reflections regarding constructive alignment of the present course will be included along with my suggestions for improvements for the new course. The evaluation comments received from the students following the course (both in 2012 and 2013) will also be included in the consideration for design of the new course.

Furthermore, I have had discussions with other teachers from the MSc specialization in Dairy Technology about possibilities for relevant teaching within the focus areas of the course, the use of external teachers, ways to find relevant literature/materials and the compatibility of the course with the others courses of the specialization.

Results and discussion

Course descriptions

When the course descriptions for the present and the new course are compared many similarities are seen. A few new topics have been specified for the new course, but the main difference is that the project work has been reduced from more than 300 hours to 80 hours. The number of ILOs has been reduced from 12 to 8, which is still quite many, but as I see it, a consequence of the demand for ILOs in three categories (Knowledge, Skills and Competences). The stated TLAs are basically the same for the two courses (lectures, practicals, excursion and project work) even though the relative amount of each might be changed. Finally, the exam has been changed slightly, putting more weight on the oral examination than previously it is changed from covering 25% to 50% of the final grade.

In terms of constructive alignment I have previously stated that the present course is fairly well aligned (Hougaard 2013), but there are issues which should receive further attention. The ILOs could be improved in formulation, and the project work may become too dominating, when the TLAs and ATs are so heavily focused on this. This raises the discussion important for most courses of obtaining the right balance between coverage and in-depth study as a result of more and more knowledge gathering within all fields. Furthermore, there is a small "course within the course" covering

the topic rheology and the placement of this topic here might need some reconsideration (Hougaard 2013). This rheology course is still included in the new DPE, since it has been evaluated that the topic is important and this is after all the most relevant placement of it.

The marked reduction in number of hours allocated to project work may seem as a reduction in a TLA where the students are the most active and responsible for their own learning, and this is also a result of the chosen compromise between coverage and in-depth study. Furthermore, in the evaluations from the course both in 2012 and in 2013 there were comments like:

"I think the project is too big… Thought too much time was allocated to this and that time would have been better spent on more teaching and a more controlled practical work so that less time was spent on it." (Translated from Danish)

"The time spent on project work was suitable. But it was the only activity there was."

"The project is almost the entire course, and this is probably too much, the lectures we had in the beginning of the course are very far away by now… " (Translated from Danish)

These comments (among others) suggest that the students actually like the project work, but there should also be room for other activities, and when the course is split in two there is not time enough to keep the big projects, but the project work will still cover almost 40% of the course workload (80 hours out of totally 206 hours).

The overall conclusion regarding the constructive alignment signaled in the course description is that the description for the new DPE course is an improvement over the old course description, but further improvements are possible, especially I would, in general, suggest ILO descriptions to be reconsidered whenever possible. The time allocated different TLAs may also need reconsideration when practical experience with the new DPE has been obtained, especially regarding the project work.

Suggested structure of the new DPE

The teaching in the course, besides the project work, has been grouped slightly based on the topics defined in the course description and types of TLAs are suggested for each group (Figure 3.1). An overview of the amount of lectures within each of the topics has been made, partly based on the

amount of lectures given within the topics also taught in the present course (Figure 3.2).

Topic (from course description)	Module	Type of TLAs
Heating Homogenization Membrane filtration	1 – General treatments used for different dairy products	Lectures, practicals/demonstrations, (excursion)
Cheese production Slicing, dicing and shredding	2 – Cheese	Lectures
Drying	3 – Drying	Excursion
Freezing (ice cream)	4 – Freezing	Lectures
Cleaning	5 – Cleaning	Excursion
Rheology	6 – Rheology	Lectures, practical

Fig. 3.1. Grouping and suggestion for TLAs for the topics covered in the new course

Lecture topic	Lecturing hours
Introduction and overview of dairy equipment	2 hours
Heating	6 hours
Homogenization	2 hours
Membrane filtration	4 hours
Cheese production	4 hours*
Slicing, dicing, and shredding	2 hours*
Drying	Excursion(s)
Freezing	2 hours*
Cleaning	Excursion(s)
Rheology	6 hours
Total	28 hours** + excursions

* These lectures are likely to be held by guest lecturers from the industry.
** A total of 28 hours is a deviation from the course description stating 30 hours. The deviation is necessary due to Danish holidays decreasing the available hours for teaching.

Fig. 3.2. Distribution of lecture hours between topics

An overview of the TLAs and ATs covering the ILOs stated in the course description is shown in Appendix A. A suggestion for ILOs for each module and the project work to state in more detail what is expected taught/learned and at which level has also been done (Appendix B), but these need to be reconsidered before use, since they now are only my per-

sonal, sometimes vague, thoughts of what needs to be learned within a specific topic.

Within the field of Dairy Technology and the MSc education with this specialization we are privileged with an industry caring very much about our activities and the education in general. Therefore, we have good opportunities for going on industry visits and also for getting guest lecturers from the industry teaching some of the topics where we have less experience ourselves in the research group.

One of the big challenges of teaching within the field of food industry equipment/processing technology is the scarceness of literature available at an adequate academic level describing the equipment and processing. There are a few textbooks within the subject, but they are relatively old and some are not even available for sale any more. Therefore, the students tend to become dependent on the lectures and maybe the power point slides or similar from the lectures, which is not optimal. The scientific papers within the topics are often primarily focused on product properties rather than equipment functionality, but so far a combination of excerpts of available textbooks, scientific papers and lecture slides have been used. This challenge is also visible in the evaluation comments from the present course (2012 and 2013):

"It (the textbook material) was OK but I miss more literature that actually describes equipment, for example I think there is nothing about cleaning of dairy equipment" (Translated from Danish)

"There was in reality no relevant textbook material besides the slides, which in general are good." (Translated from Danish)

"There is a lack of curriculum for some of the different unit operations . . . It might be a god idea to have something for further reading" (Translated from Danish)

The selection of literature for the new course should be improved compared to the present course, and some work should be put into this challenge as soon as possible, though lying outside the scope of this project. At some point it might become necessary for the teachers of this course to spend the time needed for writing some lecture notes or similar text material for the course.

Teaching/learning activities

In Figure 3.1, a number of different TLAs are suggested for the new course. These TLAs are all well-known and also part of the teaching in the present

course, except practicals and demonstration that have been kept to a minimum and the project work has been the primary hands-on activity.

Lectures

In the literature there are several reports demanding justification for the use of traditional lectures to the extent still observed in many university courses (e.g. Gibbs (1981), Mazur (1997)). According to the course description, 30 hours of lecturing is intended for the new DPE, which is around 15% of the total workload. I find this amount appropriate for the course, but the lecturers should still pay attention to their way of lecturing, since there are ways of lecturing that stimulate student learning and thinking (Trigwell et al. (1999), Mazur (1997)). Some of the lectures in the new DPE are expected to be held by guest lecturers from the (dairy) industry, e.g. the topics of cheese production and slicing, dicing and shredding of cheese (Figure 3.2). Guest lectures of this type has been used successfully previously, but in terms of curriculum for the topics and inclusion of the topics in the ATs, it might be necessary to emphasize to the visitors what is expected from them and what we expect the students to be able to do afterwards.

Practicals/demonstrations

Three practicals of 4 hours each is planned for the new DPE. Two of these are planned as demonstrations in our pilot plant facility, where technical staff from the manufacturers of some of the equipment, which is otherwise seldom used, should come and demonstrate the use of the equipment. The students should during these demonstrations participate by collection of relevant data showing the progress and state of the process demonstrated. The equipment to be demonstrated is a filtration plant for separation/concentration of products and a scraped surface heat exchanger for production of butter/margarine type emulsions.

The third practical is a more traditional laboratory practical within the topic rheology, where the students should perform different types of rheological measurements on dairy products.

Excursions

At least two excursions are planned, one covering the topic Drying and one covering the topic Cleaning. For both these topics there are manufacturers

of equipment based relatively close to the university who have expertise and willingness to let the students in and teach them, along with visits to their pilot plant and/or production facilities. The excursion to a manufacturer of equipment for drying could also be combined with a similar excursion in one of the other MSc courses dealing primarily with powder functionality, so that the company will have only one visit, but covering a whole day and cross disciplinary aspects of drying within the dairy industry from equipment manufacture to testing of product functionality.

A possible third excursion could go to a manufacturer of many types of equipment used in the dairy industry, SPX Flow Technology, and thereby deal with subjects from different modules. However, there might be some time issues in the course, making a third excursion hard to fit in, as the course is placed in the spring where the Danish holidays often fall on teaching days, e.g. in 2014 this course will lose a total of 8 hours for teaching due to Easter Monday and Whit Monday.

As stated for the use of guest lecturers inside the university, attention should be paid to the learning objectives and the inclusion of the topics in the ATs.

Project work

In the present course the students have had more than 300 hours to plan, perform and report a project. The planning and practical work has been done in small teams of 3-4 students, whereas the report has been prepared individually. In the new DPE only 80 hours has been allocated to the projects, which means that the projects need to be re-designed. There is room for approximately three and a half days (28 hours) of experimental (pilot plant/laboratory) work within the new course plan, and the remaining time should be used for planning, literature study, data analysis and report writing.

The decrease in time available for project work means that the settings around the projects need to be changed. In the present course the students choose between rather loosely defined projects and start planning their work with literature study and selection of process changes and analysis they want to perform. This often results in students asking for analysis that are not available, either due to instrument limitations or due to time limitations for training/supervision within a certain analysis. The planning part should definitely not be removed from the project work, but the projects

may need to be more tightly defined and designed to be realistically performed within relatively short time (fewer parameter changes, less analysis etc.). Possibly a list of available methods for analysis should be handed out to avoid that they spend time on finding methods which they cannot use anyway.

Assessment tasks

The ATs of the present course are almost purely summative. The students get one grade in the end of the course, where their written report accounts for 75% and the remaining 25% is based on a short oral examination. The oral exam could/should in principle cover the entire course, however, in reality this exam has had a form as a very short defense of the project report, with an oral presentation of the project followed by a few questions from teacher(s) and censor. The feedback the students get during the course is a discussion and approval of their experimental plan for the project, and possibly some discussion of results during project supervision.

According to the course description, the summative assessment in the new DPE consists of the same elements, but the weight of the project report has been reduced to 50% and the weight of the oral exam increased to 50%. It seems reasonable that the report from the project work covering approx. 40% of the course workload could account for 50% of the final grade, but from my point of view the oral exam needs to be changed to a format where it assesses the learning outcome of the other TLAs. This is also asked for in the student evaluations (2012 version):

"...It seems like you at the exam are "only" held accountable for your own project, and thereby the exam do not cover the curriculum as such..." (Translated from Danish)

In some literature regarding motivation of students to read for lectures and engage actively in TLAs there seems to be an anticipation of students being lazy, or maybe more correctly, strategic in their work, meaning that if there is no consequence of not reading and working, then they just do not do it (e.g. Gibbs & Simpson (2002)). I do not think that this is completely true, but nevertheless, I think it is necessary to assess the intended competences gained through the DPE course more broadly than it is done in the present course. It is therefore suggested that the oral exam is used to assess the other TLAs and not directly the project work. This can be done in numerous different ways and only a couple of those will be mentioned and discussed here.

The “easy” solution is to do a traditional oral examination where the student draws a question from a pile of questions and then with or without further time for preparation is tested within that particular topic. In this way the students do not know which topic they will be tested within and therefore, at least in theory, they will learn them all. The questions could deal with a process or a specific piece of equipment and the students then be asked to describe the functionality of the equipment, the type of data that could be obtained during processing and to suggest changes to the process necessary in order to change a certain product in a certain way (or vice versa). My primary concern about this form of assessment is that it might be difficult to assess high level competences intended for the course in this way, since it would be possible for the students to do much of the exam fairly well simply by rote learning of a few facts regarding the processes and equipment included in the course.

Another possible form for the oral exam is to ask the students to make some sort of portfolio from assignments and activities during the course which they have to present at the oral exam and answer questions from teacher(s) and censor within. The students will then need to hand in the portfolio as well as the project before the exam and they might find this being too much, even though the materials for the portfolio should have been prepared during the course, they do still need to do the selection of it and deliver it in a presentable manner. This type of assessment is according to Biggs (1996) strongly implicated in the constructivism in learning, since the students need to select and provide evidence that they have obtained the intended learning outcomes.

Besides the changing of the oral exam, I would also like to introduce some formative assessments during the course. Formative assessment is done during learning (Biggs & Tang 2011) with the overall purpose to contribute to the learning process by informing the students about their performance (Yorke 2003). Formative assessment may also be called formative feedback, and the importance and efficiency of timely, sufficient, interactive feedback between students and teachers has been emphasized by a number of authors (e.g. Yorke (2003), Black & William (2001), Gibbs & Simpson (2002), Biggs & Tang (2011)).

As mentioned previously, some form of feedback is already given on the project work in the present course, as the students need to present a project plan to the supervisor and receive feedback on the outline and quality of this plan, and an approval of the project plan is needed for the practical work to start. This feedback should continue in the new course, so it still is required

to prepare a project plan that is reviewed and commented on by the project supervisor and when sufficient, approved by the supervisor. Furthermore, some more formal supervision during the project preparation should also be included to provide feedback on the work progress, data interpretation etc. This has also been asked for in the student evaluations of the present course (2013):

"... More consultation with tutor on project progress to ensure analysis methods etc. are the correct ones chosen and ensure project is moving in the correct direction."

In module 6, rheology, I suggest that some sort of test is included in the teaching material, possibly design a test that can be done in Absalon (the course homepage). Such test could provide the students (and the teacher) with information on whether they have grasped the ideas of this topic, and the individual student could figure out what he/she specifically needs to improve his/her skills within.

I have had certain difficulties in finding ways of formative feedback for the remaining modules without introducing excessive amounts of work on the teachers. I have thought about introducing some sort of reflection paper for each module and some peer assessment of these, but I have not so far been able to design a format of this, which I believe that the students will engage in. Small assignments within the module topics could also be developed, but they would still need to be assessed and discussed in some way.

Conclusions, reflections and perspectives

The aim of the present paper was to re-design the course Dairy Processes and Equipment from a 15 ECTS thematic course into a 7.5 ECTS course covering the dairy specific part of processing and equipment and supplementing another new 7.5 ECTS course covering processing and equipment in the food industry more generally.

One major change in the new DPE course is the decrease in the amount of time spent by the students doing project work in teams, but there is still room for the project fulfilling some of the intended learning outcomes of the course. There is also coherence between the projects' part of the course workload and the weight of the project in the final assessment. Many of the lectures in the present course can be moved more or less directly into the

new course, though it is still recommended for the teachers to pay attention to their ways of lecturing and activation of the students.

Laboratory/pilot plant practicals/demonstrations have been introduced in order to ensure that the students get broader practical skills than in the present course, where this is primarily obtained through the project work.

Finally, the assessment tasks of the course have been evaluated and changes are definitely needed. The weight of the project report has been reduced, and the oral exam is suggested to be re-designed to cover the other teaching/learning activities of the course, but decisions still need to be done on the actual format of the oral exam. Introduction of more formative assessment is also suggested, but more work needs to be done in designing a format that the students are likely to engage in without adding too much work on the teacher/course responsible.

The structure of the new course has been designed with the aim of improving the constructive alignment of the course compared to the present course and trying to incorporate new topics and TLAs also based on the previous students' suggestions for improvements to the course in their evaluation responses given at the end of the courses in 2012 and 2013.

This project is only the first step in the work that needs to be done to change the course and improve it. More work is needed in the detailed planning of excursions, demonstrations and guest lectures, but it should be possible to plan an improved course for 2014, which could serve as basis for further improvements for future courses.

A An overview of the TLAs and ATs covering the ILOs stated in the course description

Category	Course Intended Learning Outcomes	Teaching/Learning Activities	Assessment Tasks (f/s)*
Knowledge	Identify and describe the principle(s) behind the processes and equipment needed in production of dairy products	All lectures and excursions module 1-5 Practicals/demonstrations Project work	Assignments/reflection paper – peer assessment (f)** Final exam – project report Final exam – oral examination
	Explain the effects of dairy processes and equipment on the molecular, physical and chemical properties of dairy products during the different stages of processing	Practicals/demonstrations Project work	Assignments/reflection paper – peer assessment (f)** Approval of project plan (f) Final exam – project report (s) Final exam – oral examination (s)
	Possess comprehension of the flow and rheological properties of fluids and elastic materials based on knowledge from physics and chemistry	Lectures module 6 Rheology practical (Project work)	Absalon test (multiple choice?) (f) Final exam – oral examination (s) (Project report (s))
Skills	Analyze complex unit operations and processes in the dairy industry and apply previously obtained knowledge of physics and chemistry to them	Lectures module 1-5 Practicals/demonstrations Project work	Assignments/reflection paper – peer assessment (f)** Final exam – oral examination (s) Final exam – project report (s)
	Apply relevant methods for characterization of physical and chemical properties of dairy products and analysis of data	Project work	Approval of project plan (f) Final exam – project report (s)
	Structure a scientific report based on primary literature and obtained experimental results	Project work	
Competences	Collect relevant data in dairy processing lines for monitoring and identifying changes in chemical and physical properties of dairy materials during processing	Practicals/demonstrations Project work	Assignments/reflection paper – peer assessment (f)** Final exam – oral examination (s) Final exam – project report (s)
	Work in a group to structure research work an report writing	Project work	Approval of project plan (f) Final exam – oral examination (s) Final exam – project report (s)

*f: Formative assessment; s: summative assessment

**The structure of this AT needs further considerations before introduction

B Suggestions for ILOs for the modules of the new "Dairy Processes and Equipment"

Course module	ILOs
1 – General treatments used for different dairy products	Describe the principles of heat treatment, homogenization and filtration processes and the equipment needed
	Explain the differences related to different types of dairy products
	Collect and analyze process data
2 – Cheese	Describe equipment used for cheese production and cheese cutting
	Explain differences between equipment types and relation to cheese quality and process efficiency
	Discuss problems and solutions in slicing, dicing and shredding of cheese
3 – Drying	Describe the principles of drying processes and equipment used in the dairy industry
	Discuss the relation between processing parameters and product quality
4 – Freezing	Describe the process and equipment used in ice cream production
	Explain the effects of changing processing parameters on product functionality and quality
5 – Cleaning	Describe cleaning processes and principles applied for different types of equipment
6 – Rheology	Describe viscous, elastic and viscoelastic properties of foods and methods for analysis
	Discuss the relevance of rheological parameters for characterization of different types of dairy products
	Apply rheological analysis methods to dairy products and interpret the results in terms of product properties
Project	Plan and conduct experiments in teams
	Investigate, document and communicate effects of changing processing parameters on product properties and functionality
	Apply relevant literature to explain observed effects

All contributions to this volume can be found at:

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The bibliography can be found at:

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