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Improving the quality of laboratory learning in *Pharmaceutics I* through constructive alignment of the course design in relation to the complete Bachelor's Program in Pharmacy

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Introduction

At the School of Pharmaceutical Sciences at the University of Copenhagen, students spend a substantial amount of their time in the laboratory. At the Bachelor's Program in Pharmacy, 30% of the time is allocated to laboratory work (Københavns Universitet, 2019). Laboratory work is generally considered an essential part of the natural sciences educations, as the laboratory offers ideal settings for students to achieve a high-level content understanding while acquiring competences related to doing science Hofstein, 2017. However, as teaching in the laboratory is very resource consuming, and university funding have been decreasing during the past years, it has become increasingly important that the quality of laboratory learning is high.

In the course *Pharmaceutics I - Liquid and Semi-Solid Dosage Forms*, 230 fourth semester students has to learn how to design, manufacture, evaluate, and use liquid and semisolid dosage forms (Kurser, 2019b). The majority of the course (2/3) is spend in and around the laboratory, where the students complete four exercises, each focusing on specific types of dosage forms. In the present setup, the student have to discuss design and use of the dosage forms relevant for each exercise before going in the laboratory, where they manufacture and evaluate these dosage forms themselves. In the laboratory, the students are supposed to learn specific skills associated with dosage form manufacturing and quality control testing. Following each exercise, the students have to write a scientific report documenting

their work, i.e. presenting, and discussing their results (app. 10 pages of writing plus 10 pages of batch documentation). The students are asked to give written peer-feedback on each other's reports, and all reports needs to be approved to pass the course. The last part of the course (1/3) consists of lectures and auditorium sessions, in which the theory behind the design, manufacturing, evaluation and use of liquid and semisolid dosage forms is presented and discussed. At the exam, the student's competences in relation to designing, manufacturing, evaluating, and using liquid and semisolid dosage forms are tested in a three-hour written exam. Approximately 40% of the students fail the ordinary exam every year, with 50% failing the re-exam. The high failure rates stress the students as well as the teachers, as they increase the workload associated with the course. Furthermore, it is my impression, that the high failure rates make most of the students nervous about the exam/re-exam, which negatively affects their performance. From this short description, it is apparent that the course is not firmly aligned, i.e. several teaching/learning objectives are introduced during the course, which are not tested at the exam (e.g. writing a scientific report and giving peer-feedback).

While it is widely believed that laboratory work provides a unique opportunity to develop certain kinds of skills, abilities and understanding, there are many research studies, essays and reviews criticizing the tradition of conducting experiments without a clear purpose and goals (Hofstein, 2017). It has been claimed, that much laboratory work is purposeless, and that the explicit objectives of the practical work often do not coincide with the purpose of the practical experiences. Furthermore, many practical tasks have too many different teaching/learning objectives for the students to focus on during instruction (Hofstein, 2017), which means that the general focus might be lost, and that the students end up learning much less than intended. According to Hounsell and Hounsell, students tend to focus their energy on the aspects of a curriculum, which appear to be most crucial for passing the exam, when faced with an "unmanageably large syllabus" (Hounsell & Housell, 2007). Based on this, it is assumed that students will tend to focus their energy on elements directly related to the exam during laboratory work, especially if too many different teaching/learning objectives are presented in association with the laboratory work. Therefore, if a given skill, ability or understanding is not evaluated during the exam, the students cannot be expected to acquire it, even if the teachers spend a lot of time and energy instructing this particular skill, ability or theory.

From my point of view, the pharmacy students struggle with each element of the *Pharmaceutics I* course, i.e. with achieving the required competencies in relation to passing the exam, with the scientific writing necessary to have their reports approved, as well as with acquiring the instructed laboratory skills associated with dosage form manufacturing. Furthermore, I worry, that the scientific report structure of the lab-reports confuses the students in such a way, that they are unable to see the resemblance between the lab exercises and the exam. When the reports are evaluated, both by peer-review and by the teachers, a lot of time is spend on discussion the correct structure of a scientific report relative to the theory behind the experiments and e.g. reasons for high dose variations, or the use of a specific technique for manufacturing gels. As the scientific writing is not evaluated at the exam in *Pharmaceutics I,* it is my belief that the students spend the absolute minimal amount of time on this task, and therefor do not achieve the desired learning outcome. Furthermore, as the students still have to complete the task, i.e. write four 10-page scientific reports, they might also lose focus on learning the required competencies evaluated at the exam. Overall, this might mean that the multiple different teaching/learning objectives of the course produce confused students who are presented with the unique possibility of learning hands-on how to design, manufacture and evaluate dosage forms, but are incapable of obtaining the intended high level understanding of these procedures, due the multifaceted complexity of the course design. To evaluate, if this is (somewhat) true, the purpose of this project was to assess how the present course design (in accordance with the present course description) of *Pharmaceutics I* (Kurser, 2019b), affects the students perceived laboratory learning in relation to passing the exam.

As several elements of the *Pharmaceutics I* course, e.g. the scientific writing, are interdisciplinary elements forming the basis of the skills- and competencies profile of Bachelor's in Pharmacy (Københavns Universitet, 2019), it is important to consider the structure of the entire Bachelor's Program, in order to ensure that these elements are taught appropriately throughout the three-year program. To avoid complications on the Bachelor's level associated single course structure changes, the present distribution of interdisciplinary skills taught in *Pharmaceutics I* throughout the Bachelor's Program in Pharmacy was mapped. Due to the limited size of the present project, only the following skills were included; reading scientific literature and extracting relevant information, using relevant databases, communicating scientifically both orally and written, using peer-feedback, documenting laboratory work (using a lab. Journal), work working safely

in a laboratory according to GXP, and working independently and as part of a group (Table 13.1, appendix A). The skills were extracted from the skills-profiles presented in the "2016-studieordning for batcheloruddannelsen i farmaci ved Det Sundhedsvidenskabelig Fakultet ved Københavns Universitet" (Københavns Universitet, 2019), and selected based on relevance with respect to *Pharmaceutics I.*

Designing an intervention to improve the quality of laboratory learning in *Pharmaceutics I,* while staying in accordance with the curriculum of the Bachelor's Program in Pharmacy

To map the present distribution of the selected interdisciplinary skills taught as part of the Bachelor's Program in Pharmacy, the course description of each course taught during the first five semesters of the program, was carefully studied (Kurser, 2019b, and in references). Table 13.1 displayed in appendix A, shows the distribution of teaching focused on interdisciplinary skills, as specified in the course descriptions (see reference list). Colored boxes indicate that the skill in question is mentioned in the course description (yellow and green). Green boxes indicate that the skill is mentioned both in the general description, and as part of the evaluation, (typically by pass/fail). As it was not possible to evaluate the actual time and energy associate with the various interdisciplinary skills based on the course descriptions alone, a group interview with four fifth-semester pharmacy students was conducted (1.5 hours of duration). The interview guide is available in appendix B. Notes from the interview directly relating to the mapping of the interdisciplinary skills are included in 13.1, and additional quotes regarding the structure of *Pharmaceutics I* is available in appendix C.

From 13.1 it is apparent that most of the selected interdisciplinary skills are well-represented and well-distributed throughout the Bachelor's Program. Some discrepancies between the course descriptions and the student experience were observed, and in some cases the students clearly stated that too much time was spend focusing on the skill in comparison to the general topic of the course. Especially, with respect to writing long scientific reports, two courses was singled out as courses where too much time was required to write reports; *Pharmaceutics I* and *Evaluation of Pharmaceutical Substances* (table 13.1). Based on a student quote stating that the student completely lost her focus on the course while writing reports,

clearly stress a possible negative effect of allocating too much time to long scientific writing; " *I think you totally forget about participating in the course when you do these projects because you spend so much time on them*" (appendix C). Though the students may benefit from the writing process in terms of improving their scientific writing skills, the loss of focus on the theoretical aspects of the course may be catastrophic, especially in the course *Pharmaceutics I*, where the student really struggle with learning the basic theory of designing, manufacturing, evaluating, and using liquid and semisolid dosage forms. As the mapping of the interdisciplinary skills (table 13.1) showed that the students have to write long scientific report in approximately every second course throughout the Bachelor's Program, there appears to be no reason for the large amount of time spend on writing scientific reports in *Pharmaceutics I*.

Changing the course structure

Based on the results of the present project, I have proposed several changes for the restructuring of *Pharmaceutics I*. I have discussed my suggestions with the course team including the course leader, and we have agreed to implement the following changes related to interdisciplinary skills (on a trial basis) next year:

- The scientific report writing is heavily reduced; instead of preparing four 10-pages reports, the students should only prepare one report with a scientific report structure. The remaining three reports are replaced by "simpler" question/answer-type reports with questions resembling exam questions. With this change in the course structure, I believe the congruence of the course, i.e. the connection between the lab work and the exam, will be more apparent to the students. Furthermore, the anticipated work-load reduction is expected to free more time for the students to contemplate the theory connected to the design, manufacturing, evaluation, and use liquid and semisolid dosage forms.
- The peer-review segment is altered to be oral, and reduced due to the simpler structure of the lab. Reports, with a specific focus placed on batch documentation. All reports are handed in to the supervisors 1 week AFTER peer-feedback, i.e. the students help each other improve the reports. Additionally, the purpose of the peer-feedback is introduced in a lecture, to stress it's importance early in the course. By minimizing

the peer-review task, and giving the feed-back orally to improve the reports, it is expected that student will spend enough time to give a more fair evaluation of each other's work, and the better reports are handed in. As very specific guidelines are available on how to do batch documentation, it should be easy for the students to find each other's mistakes, and learn from them.

- Fewer exam questions will be looked at during each auditorium sessions. This change is expected to ensure more detailed explanations and discussions regarding the solution /approach to solve a given pharmaceutical problem.

Further changes focusing on the lab schedule and the student-teacher ratio in the lab, are in process, however, as these changes are not directly related to the course structure, they are found to be outside the scope of this report. Overall, the structural changes of the course is expected to increase the congruence of the course and thereby, hopefully, improve the quality of the laboratory learning in *Pharmaceutics I* allowing more student to pass the course at the ordinary exam.

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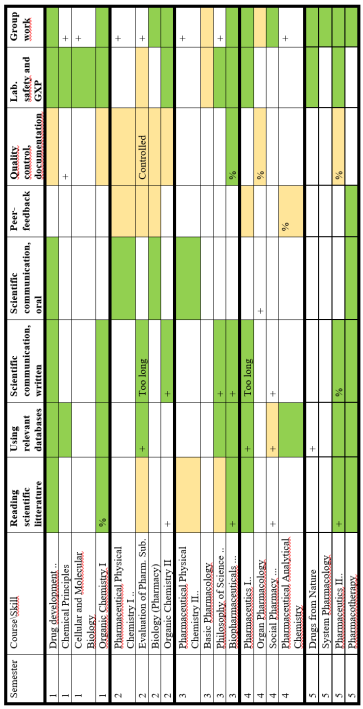
A

Table 13.1. Distribution of teaching focused on interdisciplinary skills, as specified in the course descriptions. Colored boxes indicate that the skill in question is mentioned in the course description (yellow and green). Green boxes indicate that the skill is mentioned both in the general description, and as part of the evaluation, (typically by pass/fail). Text are notes based from the student interview: "%" means that the skill was not in focus during the course, "+" indicates that the students feel the skill was introduced and tested appropriately, "too long" means that too much time was spend focusing on the specific skill relative to the other course content, and "controlled" means that the skill was controlled and needed to be approved to pass the course.



Semester	Course/Skill	Reading scientific literature	Using relevant databases	Scientific communication, written	Scientific communication, oral	Peer-feedback	Quality control, documentation	Lab. safety and GXP	Group work
1	Drug development								
1	Chemical Principles						+		+
1	Cellular and Molecular Biology								+
1	Organic Chemistry I	%							
2	Pharmaceutical Physical Chemistry I								+
2	Evaluation of Pharm. Sub.		+	Too long			Controlled		+
2	Biology (Pharmacy)								
2	Organic Chemistry II	+		+					
3	Pharmaceutical Physical Chemistry II								+
3	Basic Pharmacology								
3	Philosophy of Science			+					+
3	Biopharmaceuticals	+	+	+			%		
4	Pharmaceutics I		+	Too long					
4	Organ Pharmacology				+		%		
4	Social Pharmacy	+	+	+					
4	Pharmaceutical Analytical Chemistry					%			+
5	Degree Project		+						
5	Systems Pharmacology								
5	Pharmaceutics II			%			%		
5	Pharmacotherapy	+							

B

Group interview guide (in Danish)

Inklusionskriterier: - Farmaceutstuderende som har gennemført (eller næsten har gennemført batchelor uddannelsen i farmaci (på 5., 6. eller 7. semester)

- Må vi optage jeres svar på video/lyd?
- Ca.1-1,5 times gruppe interview (min 4 personer)

Interview guide:

Introduktion til de studerende: Jeg er næsten færdig med mit universitets pædagogikum, og laver pt mit afsluttende projekt. Projekt skal gennem belysning og udvikling af konkret undervisnings forholde sig til, hvordan studenteraktiverende undervisningsformer og fagdidaktisk/pædagogisk viden kan bidrage til at styrke de studerendes læring.

Jeg har taget udgangspunkt i faget Farmaci I, som på papiret skulle give de studerende fantastiske muligheder på læring (2/3 øvelsesfokuseret undervisning), men som hvert år har en dumpeprocent på 40-50%.

På basis af egne observationer, samtaler med studerende og kursusadministratorer på diverse bachelor fag, har jeg udarbejdet en årsagsforklaring og forslag til ændringer for at styrke de studerende læring, ikke blot på Farmaci I, men på hele bachelor uddannelsen i Farmaci.

- I min optik, er der i farmaci stort fokus på tværfaglige kompetencer, som ikke testes til eksamen. Kompetencerne er relevante for de studerende, i relation til den samlede uddannelse, men jeg føler, at de optager ALT for meget plads på dette kursus. Kan de fordeles bedre? Er der en samlet strategi? Kan en sådan indføres?
- De tværfaglige kompetencer, der er listet i 13.1 (Appendix A), er inddraget i studiet.

Gruppe interview udføres for at teste min hypotese, ved at få direkte feedback fra studerende omkring hvorledes de ser situationen! Påvirker kursus strukturen deres læring (selvopfattet)?

Spørgsmål: (Med fokus på Farmaci I)

- Hvad var (efter jeres mening) formålet med kurset? (dvs hvad tror i skulle lære?)

- Kurset er bygget op, med de fire øvelsesomgange i centrum, men består af mange studenteraktiverende delelementer (før-øvelsestimer, øvelser, rapportskrivning (videnskabelig), peer-evaluering, efter øvelsestimer, forelæsninger, opgavetimer og skriftlig eksamen).
- Hvad brugte i mest tid på?
- Hvad føler i, at i lærte mest af?
- Hvordan føler, at disse mange fokus områder påvirker jeres læring? (fjerner de fokus? Eller øger de læring gennem flere facetter)
- Hvordan passer de tværfaglige kompetencer (se ovenfor) ind i relation til resten af bachelor uddannelsen?
- Føler i, at der er en rød tråd imellem kurserne?
- Hvordan ville i optimere? (om nødvendigt)
- Er der en bestemt rækkefælge, i gerne ville lære disse kompetencer i?

C

Selected quotes from student interview (in Danish)

*O*n writing long scientific reports:
“Rapportskrivningen krævede en del, fordi vi forberedte os før lab og efter lab.”
”Jeg synes, at man glemmer at være med i faget, når man laver de her projekter, fordi man bruger så meget tid på dem.”
”En skulle være perfekt – og så resten bare er spørgsmål”
*O*n other elements of Pharmacutics I:
Peer-review gav ingen kritik: ”jeres bliver godkendt, bare fordi i er søde” ”det er pres på en anden måde, vi vil ikke gå og have dårlig stemning på holdet, forbi vi ikke godkender en rapport”
”Jeg skal være helt ærlig.. opgavetimerne, de var ikke gode. De gik ALT for stærkt. Det var bare slide efter slide efter slide, og man kunne ikke nå at forstå noget.. Kun én time var brugbar, da undervisningen her gik MEGET langsomt og have specifikt fokus på hvordan man skulle besvare givne eksamensspørgsmål. .. Vi var alt for mange til opgavetimerne i auditoriet.. personligt ville jeg aldrig nogensinde sige noget i auditoriet.. det synes jeg var ærgerligt”
”I farmaci II var der ikke så mange i lab (kun ét hold af gangen), og der var to undervisere som gik rundt og stillede spørgsmål. (. . .) altså lab i farmaci II var klar bedre. Hvis man have spørgsmål i farmaci II, kunne man bare stille dem, men hvis man havde spørgsmål i farmaci I, var der bare kø til underviseren”
”45 min opgavetimer er ALT for korte – tiden flyver afsted”
”eksamen er meget vigtig. Især fordi man har hørt de her skrækhistorier om eksamen i farmaci I og II..”
”Der må gerne være mere fokus på eksamen”
”opgavetimerne, altså i må rigtig gerne lave dem om!”
*O*n other elements:
”jeg har ikke haft en lab-journal siden 2.semester..”