Enhancing student experience and learning outcomes in a practical pharmacology course

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Abstract

This report reflects on improvements made to a pharmacology course based on student feedback and my teaching experience. Key changes included restructuring the course schedule for clarity, streamlining online materials, and modifying teaching methodologies to enhance student engagement and learning outcomes. Initial feedback indicated that students appreciated the revised schedule and materials, while changes in teaching methods improved preparation and engagement during my exercise. While average grades were slightly lower than in previous years, student understanding and satisfaction showed promising improvements, highlighting the potential for continued refinements to the course design.

Introduction

Background on course structure

The "*In vitro* Techniques in Biochemistry and Pharmacology" course is a (restricted) elective Master's level course worth 7.5 ECTS. It is offered in various MSc programs, including Pharmacy, Pharmaceutical Sciences, Medicinal Chemistry, and Environmental Sciences. Its primary focus lies in equipping students with a comprehensive understanding of *in vitro* pharmacology theory, experimental methodologies, and practical skills essential for drug discovery research. The course has been taught over several years by the same course coordinator, and the exercises have largely stayed the same, but the instructors for the different exercises have changed over the years.

The entire course spans over 10 weeks, with classes held on Mondays and Wednesdays. In practice, however, most course content happens in four core weeks. The course commences with an introductory lecture followed by a software tutorial on day one. Subsequently, the class is divided into teams, each rotating through six different exercises throughout the duration of the course.

Each exercise consists of handout material that covers the general concepts of the technique used in the exercise, along with some background material on the experiments that will be conducted. The students are expected to study this material before the 4-hour workshop conducted in the laboratory, which focuses on hands-on experience and practical application of the theoretical concepts. During these workshops, the teams collect their own data, and each team is provided with a different unknown compound that they apply in the different workshops. The workshops are each followed by 2-hour tutorials in the subsequent week, aimed at analyzing and interpreting the data collected in the workshops. The course finishes with a discussion in plenum where each group has to present data from the different exercises and make informed guesses on the identity of their unknown compound based on the results they collected throughout the different exercises.

The total workload thus divides into: Lectures: 4 h; Class Instruction: 16 h; Preparation: 158 h; Practical exercises: 28 h. The curriculum, course schedule, and material are all uploaded on Absalon. The curriculum and learning objectives are written in a comprehensive and clear way, giving the students a good idea of what they can expect from the course.

Below, the main learning outcomes of the course are summarized:

- Knowledge in *in vitro* pharmacology theory, including understanding experimental methodologies and underlying principles.
- Practical skills in research techniques applicable in both academic and biotech/pharmaceutical drug discovery research environments.
- Competencies to work with and discuss *in vitro* biochemistry techniques, as well as interpret and discuss pharmacological data with peers and professionals.

In 2023, the average grade from the final exam was 8.44, with all students passing the exam on the first try. The average score of the course from student feedback was 4 out of 5, evenly distributed over the various questions.

Motivation for improvements

In 2023, I served as an instructor for one of the exercises, and I am teaching again in the fall of 2024. While the course generally succeeds in providing students with valuable insights into widely used techniques in biochemistry and pharmacology, feedback from last year's student evaluations revealed some key challenges. The complex course schedule was named as a barrier to effectively prepare for the exercises. As a teacher, I also observed that many students arrived rather underprepared, and the time I had allocated for discussing and reflecting on their data was largely spent re-explaining basic concepts and guiding them through data analysis.

My goal is to re-examine the course schedule and explore ways to engage students more deeply with the material and improve their overall learning experience.

Problem identification

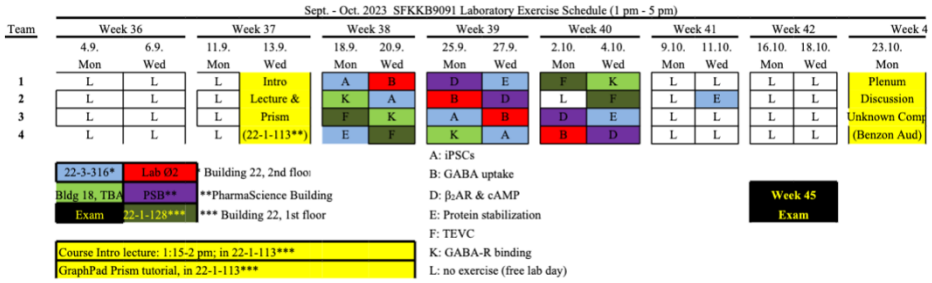
Areas needing improvements

The student feedback from last year reported: “For someone whose schedule is already packed, it was tiring and even confusing to constantly make sure you showed up at the right time and went to the right location.“ More importantly, several students pointed out that the scattering of workshops and tutorials from different exercises was challenging to keep up with: “The course was very compressed. We had all tutorials, exercises etc. in 4 weeks, even though the course lasts 8 weeks. It was very hard to navigate between three exercises in one week (e.g. Monday lab exercise B, Wednesday tutorial exercise A and lab exercise D). It was too much new information in three days, and it was hard to prepare for three different exercises with different theory in such

a short time. It would be much more manageable if all 8 weeks were spread out.“

Indeed, the uploaded course schedule is rather complex and contains separate files for the teams, the exercise, and the tutorial schedule. Furthermore, the words ‘exercise’ and ‘workshop’ are used inconsistently. While the color-coding for the exercises is helpful, they have somewhat random numbering (A, B, D, E, F, K), and room numbers and times of the exercises are placed somewhat randomly (Fig. 1).

A)



B)

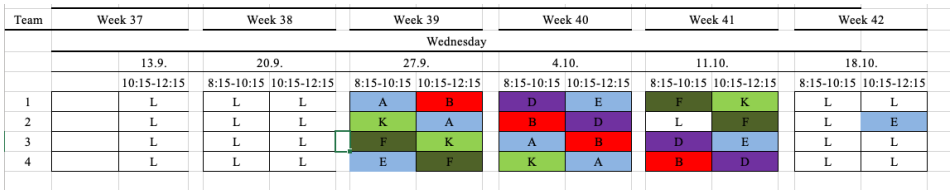


Fig. 1. Workshop (A) and tutorial (B) schedule.

Moreover, several students pointed out that the folder with the student files was rather confusing since it contained documents from previous years, and the labeling of the documents was not clear enough to prevent confusion. And indeed, when I checked Absalon, the folders were cluttered with old, irrelevant files.

The students were expected to analyze and interpret their data either during the workshop or within the first hour of the tutorial (unsupervised). This seemed to have worked well for most workshops, so the rest of the tutorial time could be used to discuss and interpret the data, answer questions, and recap the exercise. For many students, this was an essential part of their learning and helped them tremendously with getting their data ready for the final presentation in plenum. In my exercise, I felt like we still needed a big chunk of time to go through how to plot the data

they collected. Based on some of their statements during the tutorial, I also realized that they had still issues understanding some of the core concepts of the method. Thus, discussing the data and reflecting upon it was too brief.

Discussion with course coordinator

I sat down with the course coordinator to discuss some of the concerns mentioned earlier. This course has been around for many years, and in the beginning, there were very few elective courses, which meant much higher participation rates. Classes were divided into six or seven teams of five students each, and to accommodate all teams rotating through the exercises, the course had to run over 10 weeks. Today, there are many more elective courses available, leading to fewer students per course. While the workload has remained the same, this change has effectively shortened the time needed for the course to run. In previous years, the schedule was adjusted to make it less condensed, resulting in some Mondays and Wednesdays being free between exercises. However, student feedback was largely negative, with some students missing their exercises due to confusion over the schedule. To address this, the exercises are now condensed into four full weeks for each team.

We also talked about the outdated material still floating around on Absalon. While the course coordinator can remove some of it, it's not always clear if the exercise instructors want to keep those files. The responsibility for clearing out old content hasn't been clearly defined. While talking about the course, I noticed some level of hesitance to change anything major about it since student satisfaction is overall relatively good.

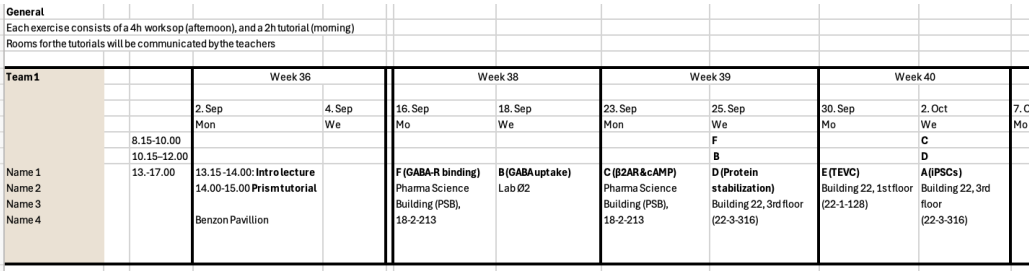
Action plan

Restructuring of course schedule

While I initially considered spreading the exercises over more weeks to improve student preparation, my discussion with the course coordinator clarified that this might not be the ideal solution. Although the current schedule is compact, it already incorporates some elements of effective

learning design, such as combining learning sessions to maintain focus and minimize disruption (Biggs and Tang 2011; Dávila 2017). At the same time, the distribution of the different elements (preparation, workshop, and tutorial) of each exercise over time leans on spaced learning, which promises to enhance long-term learning and improve retention (Benjamin and Tullis 2010).

To at least make the schedule more accessible for students, I combined the three separate documents ('teams,' 'exercise schedule,' and 'tutorial schedule') into one streamlined document, organized by teams. The updated schedule also includes clear details on times and locations, making it easier for students to navigate and plan their activities (Fig. 2).



General

Each exercise consists of a 4h worksop (aftemoon), and a 2h tutorial (morning)

Rooms for the tutorials will be communicated by the teachers

Team 1		Week 36		Week 38		Week 39		Week 40		
		2. Sep	4. Sep	16. Sep	18. Sep	23. Sep	25. Sep	30. Sep	2. Oct	7. C
		Mon	We	Mo	We	Mon	We	Mo	We	Mo
	8.15-10.00						**F**		**C**	
	10.15–12.00						**B**		**D**	
Name 1	13.-17.00	13.15 -14.00: **Intro lecture**		**F (GABA-R binding)**	**B (GABA uptake)**	**C (β2AR&cAMP)**	**D (Protein**	**E (TEVC)**	**A (iPSCs)**	
Name 2		14.00-15.00 **Prism tutorial**		Pharma Science	Lab Ø2	Pharma Science	**stabilization)**	Building 22, 1st floor	Building 22, 3rd	
Name 3				Building (PSB),		Building (PSB),	Building 22, 3rd floor	(22-1-128)	floor	
Name 4		Benzon Pavillion		18-2-213		18-2-213	(22-3-316)		(22-3-316)	

Fig. 2 Excerpt of the proposed revised schedule design for one of the teams with all information in one place.

Updating online material

The course coordinator cleared out some outdated files and urged teachers to remove any files they do not use for their exercises. For most exercises, file numbers have been reduced by more than half, while for others no changes were made. (two extreme examples in Appendix 1).

Changes in teaching methodology in my exercise

The first year I taught the exercise, the students seemed underprepared when they arrived at the workshop. I thus gave them an introductory lecture that took close to 45 minutes to ensure they grasped the fundamental concepts. However, I found that this lengthy introduction didn't help as much as I'd hoped. During the lab workshop, my focus was then on providing them with hands-on experience with the setup and cells to collect meaningful data. Afterward, I sent them their data along with brief analysis instructions. I didn't want to provide step-by-step guidance since they are Master's students and had also attended a software tutorial

at the beginning of the course. Many had trouble with this and needed my help during the tutorial, which sometimes cut into our time for important discussions and reflections.

This year, I decided to change things up and align my exercise more closely with Bloom's Taxonomy educational goals (remember, understand, apply, analyze, evaluate, create) (Amstrong, 2010). I cut the introduction down to just 15-20 minutes, making it much more interactive and focused on helping students remember and understand the key concepts. In the lab, I briefly explained the equipment, connecting each step to the core concepts, which helped them solidify their understanding. Before we started collecting data, I prompted the students to draw the expected outcome as a group (without me being present). This really boosted their engagement and helped them apply their knowledge of the core concepts. We then ran the experiments, prioritizing discussions of concepts over extended hands-on practice. If engagement was hesitant, I tried to guide them to the answer by asking smaller follow-up questions (Christenson *et al.* 2012). This approach encouraged them to think critically about their uncertainties. It opened up opportunities to assist them with their struggles and facilitated more casual conversations about the broader research happening in the field.

Before wrapping up, I clearly communicated my expectations for their preparation ahead of the second tutorial hour. This time, I decided to provide step-by-step instructions for data plotting as I wanted to put more focus on what the analysis helps us understand. The students came in much better prepared, allowing us to dive deeper and look at figures from published literature to evaluate the data in plenary. We further discussed what next steps we could take (create) to make our experiments more impactful. At the end of the session, we reviewed the specific learning outcomes for the exercise to incorporate David Boud's ideas on self-assessment, encouraging students to reflect on their learning experiences and take ownership of their education (Boud and Falchikov 2006).

Finally, I revised the exam questions to emphasize application, in line with Bloom's focus on higher-level thinking.

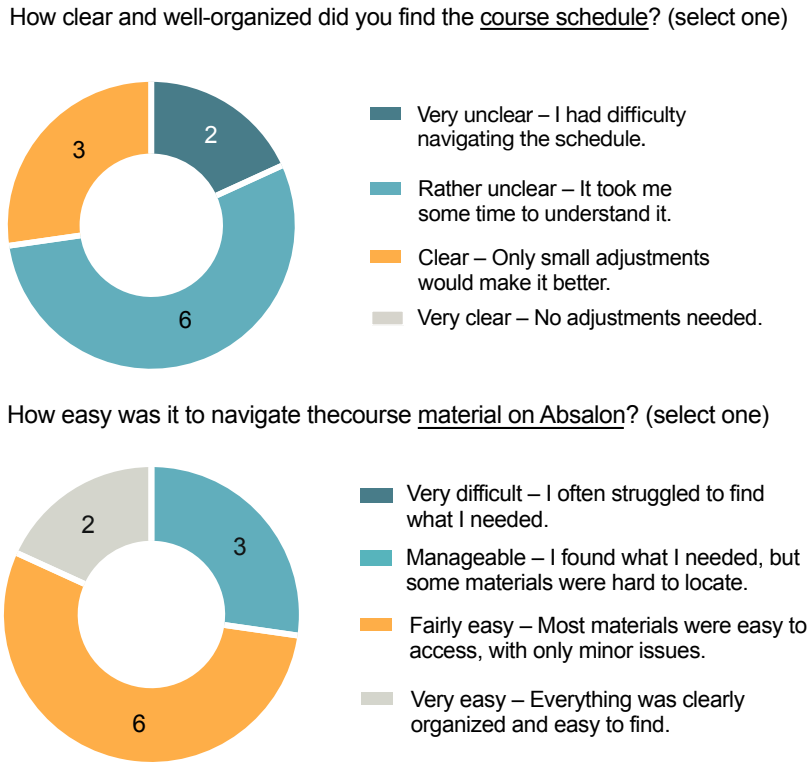
Student feedback

To gain a better understanding of students' opinions on the course schedule, the materials available on Absalon, and their experiences in my exercise, I asked the students who had completed my exercise to anonymously respond to a 5-question questionnaire on Mentimeter at the end of their tutorial. I also presented both the old and new schedule designs to the students and asked for their feedback directly. Additionally, I asked whether they would have preferred more hands-on experience in the lab compared with discussing concepts. Furthermore, I will report on my own experiences and the impact of these changes on the interaction with the students.

Outcome

Reaction to course schedule and course material

Of the 15 students that attended the course, 11 answered the survey which showed the following results (Fig. 3):



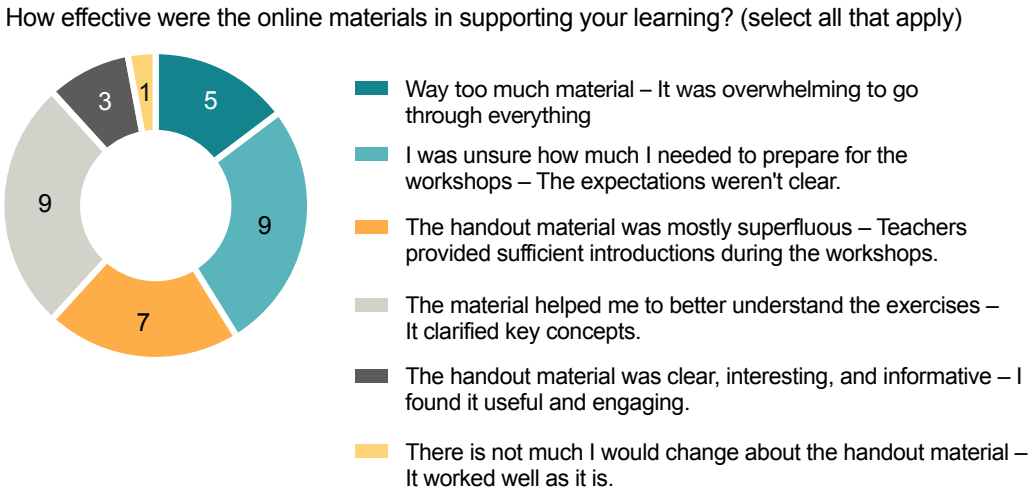


Fig. 3 Three of the four multiple-choice questions that the students answered anonymously after the exercise.

The students' responses clearly indicated that the original course schedule was confusing. All students who were shown the revised schedule preferred it, agreeing that it would make navigating the various components of the course much easier. Feedback on the materials uploaded to Absalon was largely positive, suggesting that the clean-up had a noticeable impact. Regarding the content of the course materials, nine out of eleven students stated that the materials helped them better understand the exercises. Conversely, seven students also said that the material was rather superfluous, given that the teachers explain everything in any case. Nine students reported uncertainty about the level of preparation expected by the teachers at the start of the exercises. This concern was echoed in the open-ended question about what they would change about the course, with six students mentioning they would have liked clearer guidance on how prepared they were expected to be, as the expectations set by teachers seemed to vary significantly (see Appendix 2 for all answers).

Student engagement and satisfaction in my exercise

This year, my experience as a teacher was significantly more positive compared to the previous year. I felt much more confident in the approach

I took during the workshop, and the students remained consistently engaged throughout. I gained a clearer sense of how well they understood the concepts and which areas sparked their interest, allowing me to adapt the workshop in real-time. They also did not mind having relatively little hands-on experience since the workshop was still very interactive. The students also came better prepared for the tutorial, and I felt they left with a solid grasp of the exercise's concepts. Our conversations felt natural, and several students offered unprompted positive feedback about the overall experience. The students were excited to test whether the unknown compound had any effects on the two protein targets we explored, with some even setting up bets. I was pleased to see that they all rated the tutorial as either 'very' or 'extremely helpful' (Fig. 4). After the course, two students voiced interest in joining our lab for a Master's thesis project.

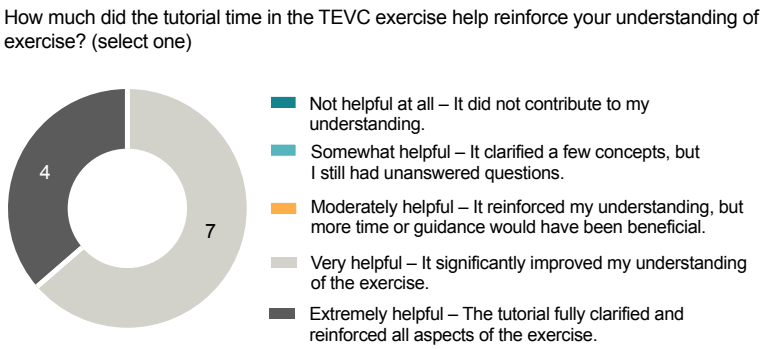


Fig. 4 Student answers to the multiple-choice question about the quality of the tutorial in my exercise.

Exam results and official student evaluation

The average grade for the course was 6.5, with all students successfully passing on their first attempt. While this is lower than the four-year average of 7.4, it is comparable to that of 2021 (6.4). However, direct comparisons are challenging due to the small group size and variations in teaching staff. Student performance on questions related to my exercise showed improvement compared to the previous year. Official student evaluations are only conducted biennially. This report is shared with the course responsible and it will be interesting to see any changes in student satisfaction next year.

Conclusions

Reflection on the changes

The updated course schedule should be implemented. The effort required is minimal, and it will likely make it easier for future students to navigate the exercises. Additionally, the ongoing effort to clean up files on Absalon should continue to ensure that materials remain clear and accessible.

One of the most positive outcomes for me was the shift in the student-teacher dynamic during my exercise. I felt much more confident, engagement and interaction were high, and it was encouraging to see that the students also had a positive experience. That said, there may be some bias in their feedback, as the questionnaire was completed during our tutorial and my presence could have influenced their responses. Since I won't be teaching this course in the future, I have informed my successor about my new approach and the benefits I've seen with it.

One of the most challenging aspects of the course, as raised by both students and instructors, is how prepared students are when they arrive for the exercise. I've personally faced this issue and two other teachers I spoke with shared similar concerns. We expect students to be well-prepared, which is why we provide all the necessary material in advance. However, some students still struggle or are not prepared, leading us to repeat important information at the start of the tutorial. This can feel redundant for everyone involved and eats up time that could be spent on deeper discussions. Interestingly, despite many students acknowledging this challenge this year, it didn't appear in last year's course evaluations, which suggests a disconnect between what students express during the course and what they formally report, or between the two years.

Next steps

While students generally appreciate the course, and the course coordinators may not see the need for significant changes, some smaller improvements could be easy to implement. One of the most important

steps might be to improve communication regarding the teachers' expectations of the students. The course functions effectively as a flipped classroom, meaning that student preparation hinges on a mix of extrinsic and intrinsic motivation, as outlined in self-determination theory (Ryan and Deci 2000; Talbert 2018). To enhance extrinsic motivation, we could limit the handout material to a specific number of pages or provide a clear list of key concepts the students are expected to grasp before the start of the exercise. Alternatively, we could introduce a short quiz or student presentation at the start of the workshop.

Intrinsic motivation may vary among students and exercises, but including real-life examples and rationale for each technique's relevance at the beginning of the handout materials could spark more interest. This small change might encourage students to engage more deeply with the content and arrive better prepared for the exercises (Jang 2008).

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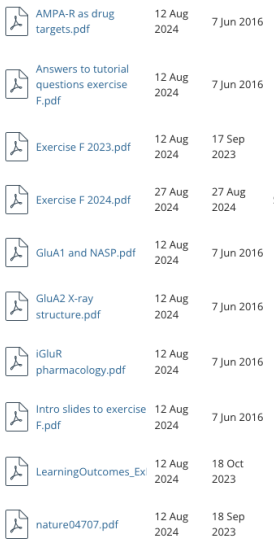
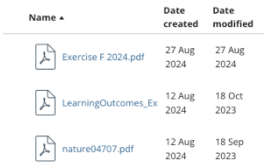
Appendix

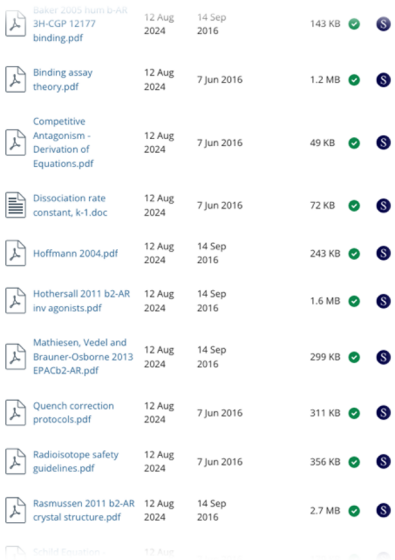
Before



After



Before and after (no change)



Appendix 1 Examples bsalon pages (before and after a cleanup)

I need more information upfront as to how prepared I should be.	little bit higher expectations of students. make sure that the expectations are even among all teachers. (excersize K's tutorial was incredibly hard compared to the rest.
Be a little more concise regarding regarding expectations to the students. A little more clarification regarding exam material, and not just say the whole manuel	it would be hlepful to have learning outcomes for all exercises
Some teachers expected us to know a lot before the exercise while others explained the very basics. They should talk to eachother	an introduction to all exercises would be nice, then we could do more practical things in the lab
Before the start of the exercise, I didn't quite know how much I should prepare for each exercise.	In many exercises it would be nice if both tutorial hours were supervised since data analysis was often not so easy.
For teachers: if you don't state your expectations on us, then don't be mad at us if we don't live up to it.	many lab exercises were mostly pipetting and not much doing the actual technique.

Appendix 2 Student responses to the question: What is the one thing you would change about the course as a whole? *(Open question)*