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Problem based learning in the online classroom

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Problem based learning (PBL) is the teaching about a subject evolving around a central problem or case study. It was originally designed to increase learning for medical students in the mid- 1960s, where medical problems were presented to the students, who had to figure out what diagnosis to give (Norman & Schmidt, 1992). In this essay I will examine how PBL can be adapted to teaching in basic science as well as the online classroom.

Problem Description

Basal pharmacology is one of the mandatory courses in the bachelor of pharmacy program at University of Copenhagen (See box 1). It is the essence of what a pharmacy student needs to learn and needs to be good at. Yet a lot of students struggle, the failure rate is high and with a low average grade.

I recently examined the congruence between curriculum-aims-scope-structure of the course and found that there was a higher ratio of pharmacokinetic calculations in the exam than in the curriculum, and that the students typically struggle more with these types of questions. There are already initiatives to increase the awareness of these questions in the exam, and classroom teaching to help the students do the calculations, yet it has not yet had a big impact.

BOX 1

Basal Pharmacology

Students: Up to 210
Nominated to: 210 hours
3rd Semester
Themes:
1) Introduction to pharmacology
2) Nerve/muscle physiology
3) Pharmacokinetics and dynamics
4) Receptor pharmacology

7 Teachers, 4 Tutors and 4 TAP
Examination: Laboratory part + 3 hour written exam without books.

I will focus on 3 questions related to the congruence between curriculum-aims-scope-structure of the course.

- What do the students think about the course basal pharmacology in general? Is there alignment between learning goals and actual teaching?
- Could problem based learning be used in the teaching sessions to increase congruence, engagement and thereby knowledge?
- Can problem based learning be incorporated into online teaching with 100+ students?

In order to answer these questions, I will collect empiric data from the students doing the basal pharmacology course in the autumn semester. I will formulate questions related to overall level and congruence of the basal pharmacology course in general. Then I will redesign my teaching sessions to be more problem based, with a video case presentation, and discuss the pros and cons of this approach especially in a large course setting.

Is there constructive alignment in the Basal Pharmacology course?

Pharmacokinetic and pharmacodynamics (PKPD) calculations covers 30% of the knowledge, 75% of the skills and 30% of the competences of the

learning goals in the Basal Pharmacology course (described in box 2) and constitute about 70% of the examination questions in the written exam. Yet PKPD calculation only constitute about 50% of the teaching sessions. It seems that there is a misalignment between the learning goals / exam and the teaching within PKPD calculation in the basal pharmacology course, and that this might be an underling reason why students struggle with the exam.

BOX 2

Learning goals in the Basal Pharmacology course

Knowledge

- Describe basal anatomical nomenclature
- Know of animal ethic principles and laboratory safety
- Reference terms of physiology and basal pharmacology and use then in the right connections
- Reflect about and understand receptor pharmacology and signaling cascades
- Describe the physical and structural properties of drugs and their effect on PKPD processes
- Understand PKPD processes

Skills

- Make PKPD calculations and interpretation of the results
- Use experimental methods and show knowledge of the principles in experimental design
- Make PKPD calculations from preclinical data and included them into physiological and pharmacological problems
- Use IT tools to fit PKPD models and statistical analysis of pharmacokinetic and pharmacodynamics data

Competences

- Have a practical approach to uncover scientific questions within pharmacology and physiology
- Make critical assessment of preclinical as well as clinical pharmacological data
- Independently identify, analyze and solve scientific problems and questions within pharmacology and physiology

A student poll showed that more students struggled with pharmacokinetics and pharmacodynamics than the other themes and that 40% of the student's think that there was a limited congruence between the themes (figure 6.1).

Fig. 6.1. Left, results from student poll on the difficultness of the different themes. Right, results from student poll on the congruence between the themes.

Empirical data was collected from the student's course evaluations. The course is generally rated quite well, yet it seems that this misalignment is repeated in some of the comments. It is evident from the comments that the students find the pharmacology lectures boring and the receptor lecture a repetition, and would like them replaced with more hands on exercises and calculations.

Examples from evaluation:

- *Student 1: Pharmacology lectures were boring and I wish that the equation walkthrough would have been as a class teaching.*
- *Student 2: There was too much repetition from the course Cellular and Molecular Biology; less time on repetition of the basal biology would be good.*
- *Student 3: There could be more hands on exercises, in the class teachings a lot of the information was on slides, which would have been better in the lectures and replaced with examples and exercises in the class teaching.*
- *Student 4: It would be useful if the receptor-lectures were replaced with pharmacology class teaching with calculations.*

What can be done to increase congruence and student learning?

It seems that Basal Pharmacology is an overall pretty well rated and good course. However students do struggle with some of the basic learnings of

pharmacy, especially the pharmacokinetic and pharmacodynamics calculations. Some novel thinking and restructuring might improve the lower congruence and the comments from the students about repetition and more hands on calculations. My idea would be to combine themes and use a more problem based learning approach to address the hand-on wishes. Problem based learning (PBL) was originally designed to increase learning for medical students in the mid-1960s. According to Norman and Schmidt, 1992, PBL does not improve learning in general; actually it may reduce initial levels of knowledge, but may foster retention of knowledge. However, the real benefit of PBL is that it may enhance transfer of knowledge concepts to new problems; intrinsic interest in the subject and self-directed learning. A recent Chinese study showed an increased self-learning ability of students (Yang et al., 2020).

How to use PBL in Basal Pharmacology?

I think PBL can be adapted to basic science teaching with the presentation of problems/cases to have students increase their interest in the subject and self-directed learning which is essential for their later success in science disciplines. It is important that while self-learning, students can receive feedback and guidance on the subject to quickly correct conceptual knowledge. For this reason, PBL often involves group work and discussions in a classroom setting, which is a challenge in online teaching.

A way to included PBL in science teaching is by using concepts from flipped classroom, where the class is "flipped" so that the students become the center of attention rather than the "teacher" and the "teacher" is more a guide or facilitator (Schunk, 2016). This is great in an online setting where it can help to reduce and make screen time more efficient. Anders Schunk talks about a video to introduce the subject in flipped classroom, however this can be used more broadly to think of it as an introduction of a scientific problem, be it video, a short lecture on a case, publications or practical problems. It can be included in the different version of flipped classroom, but probably work best if the term video is understood more as "problem introduction" in the broadest sense.

It could look something like this:

It does require a really well constructed case or problem, preferentially one where layers can be unfolded accordingly to the student's previous knowledge. Defined learning goals and test audiences are key factors in order to develop such case problems, which, when constructed well, can be reused for future students.

I teach in the receptor pharmacology theme of the Basal Pharmacology course, a lecture on the neurotransmitter and hormone serotonin, yet in my research I do a lot of PKPD calculations on serotonergic drugs. I wanted to combine the two as a way to use PBL in the teachings of Basal Pharmacology. In this was I can reduce the repetition of the basic serotonin biology and include examples from pharmacokinetics, such as elimination, absorption and binding.

I created a case shown in the video shown in figure 6.2.

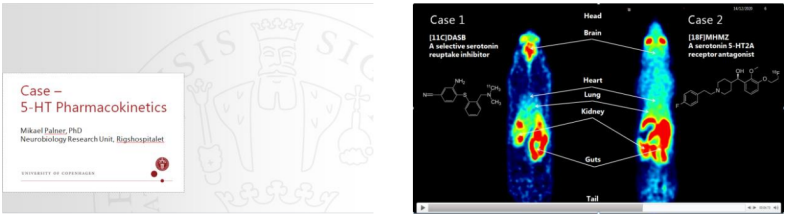


Fig. 6.2. Video case with PBL in Basal Pharmacology. Link to video: https://www.dropbox.com/s/ghushx8bvqo6th8/5-HT_pharmacokinetics_case_%28Source%29.mp4?dl=0

Following the case and lecture I did a poll to ask the students what they felt about the case and their learning outcomes. Results are shown in figure

6.3. Over 90% of the students thought the case combined receptor pharmacology and pharmacokinetics to some extent and to some extend would increase their learning outcome if extended to other themes and lectures as well.

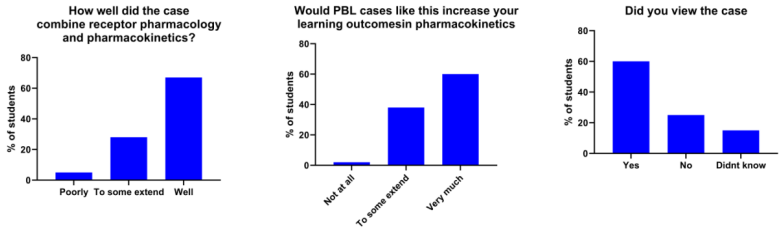


Fig. 6.3. Ending polls after the PBL case lecture.

One inherent problem with PBL is that students need to prepare to get the most out of the lecture and discussion; in this case more than 40before the lecture, in spite having received announcement's and personalized emails. Is PBL is going to be used on a larger scale successfully it needs to be part of the culture in the course and included throughout the lectures. And it may not be all teachers who feel they have the time to prepare a video case and restructure their teaching if it is already made from last year. Yet cases can also be reused and the workload of recording a video is minimal, once you know how to do it.

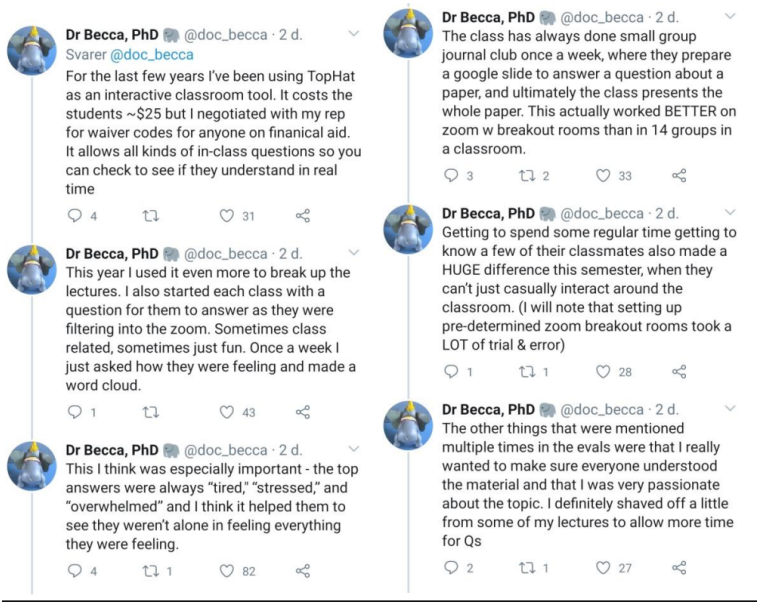
Qualitative Discussion

After the class and this report I had to chance to get additional feedback, from two colleagues who audited the teaching sessions and form two colleagues who read the report. This discussion will touch on their observations.

Teaching audit

It was a common observation that the students in the class really tried to avoid the breakout sessions. They logged in and quickly logged out again

and never turned the video on. One of my colleagues who were in a room with one student stopped the student and asked why they didn't stay in the room and worked on the exercise? The student explained "*I feel, and I know others do to, that the breakout sessions are quite anxiety provoking, as I am forced to talk with people I don't really know*", interestingly a second student who actually wanted to do the exercise joined the room and they eventually got the exercise going, but it was only after 2-3 minutes that the two students realized that they knew each other, and from there it was easier. I think this illustrate a real problem that we as teachers don't see when pushing students into breakout rooms, and I think that the use of these room or smaller groups need to be encourage throughout the semester if they are going to work well. Also the use of video is really important in the small rooms to have that physical contact and interaction that is often lacking in online teaching. To illustrate I am copying a thread from twitter about flipped classroom in courses with many students.



Dr Becca, PhD @doc_becca · 2 d.
Zoom teaching does not have the easy improvisational back and forth that classroom teaching can have. There are going to be some weird pauses and you just have to get used to that and kind of build it in. As for the 2nd thing, it's true, I get very excited talking about science.

1 1 28

Dr Becca, PhD @doc_becca · 2 d.
The bottom line I think is that especially now, students want to feel like you care, like you recognize that you are talking to real humans who are going through a whole bunch of shit and not just talking to your computer. They want interaction in all possible forms.

2 12 106

Dr Becca, PhD @doc_becca · 2 d.
Oh! One other thing I did is after the first exam, I had an "Ask me anything" class so they could get to know me better. They asked all kinds of things, from my career trajectory & research to my favorite movies and music. They seemed to like that too!

6 4 80

Dr Becca, PhD @doc_becca · 2 d.
Also if you're curious about how to do a flipped classroom journal club with 70 students I'm happy to share more details - I think they really learn a ton about reading papers and it's a great way to break up lecture days.

7 1 74

Dr Becca, PhD @doc_becca · 1 d.
OK, here is my large-scale class journal club process. I have no idea how many tweets this will take. First, for a class of 70 I divided them into 14 groups of 5. One day after lecture I sent them to breakout rooms and gave them 5 min to chat and come up with a group name.

3 6 34

Dr Becca, PhD @doc_becca · 1 d.
We had some good punny names: Pink Freud, All Fight No Flight, Myelin Nation, Hungry-Hungry Hippocampus, etc. Every time we had a journal club coming up, I would send them the paper and 14 questions that they should use to help them work their way through reading.

1 21

Dr Becca, PhD @doc_becca · 1 d.
Some example questions:

-Describe the experimental groups for Experiment 1. What is a sham surgery? Were the manipulations systemic or local?

- Figure 3-G: What was the purpose of this experiment? What did they measure? How do the results support the behavior results?

1 18

Dr Becca, PhD @doc_becca · 1 d.
More example questions:

-What flaws do you see in this paper? What would you do differently, or have the authors do to follow up?

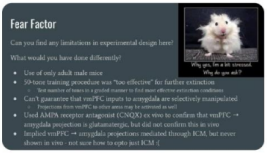
- What were the main goals and hypotheses of this study? What are your thoughts on doing parallel human and animal studies?

1 17

Dr Becca, PhD @doc_becca · 1 d.
For each paper, I created a google presentation that had 14 blank slides, each containing one of the 14 questions and having one of the group names at the top of the slide. Right before the JC class, I would share the google doc with everyone.

2 1 19

Dr Becca, PhD @doc_becca · 1 d.
They would look to see which question their team had been assigned, and then they had 15 minutes in breakout rooms to fill in the slide and answer the question. They always did a great job and had fun with the slide design



1 29

Dr Becca, PhD @doc_becca · 1 d.
After the 15 minutes were up, a representative from each group would present their slide, in order so that we effectively went through the whole paper. I would maybe ask some questiosn as they came up or add some additional info if needed.

2 16

Dr Becca, PhD @doc_becca · 1 d.
That is basically it! At the end the class had created a full slideshow on the paper that they could study from. I think it's fun to have a class in which there's a tangible "product" at the end. Learning to read papers critically is IMO one of the most important skills.

Fig. 6.4. Twitter thread on large online flipped classroom.

The take home message is that groups of unknown people are frightening to some and that it is extremely important to keep a systematic breakout room system, where it is the same people in the same discussion groups over the whole course. I think the system used in the twitter thread is great, and something I will take with me for the next semesters.

Report feedback "what made me wonder"

Colleague 1: *I wonder if the student's experience of understanding the subject better correlated with the exam outcome. Not because exams are the best outcome, but because it is the only real paramenter we can measure. And secondly how can we get the students to prepare better?*

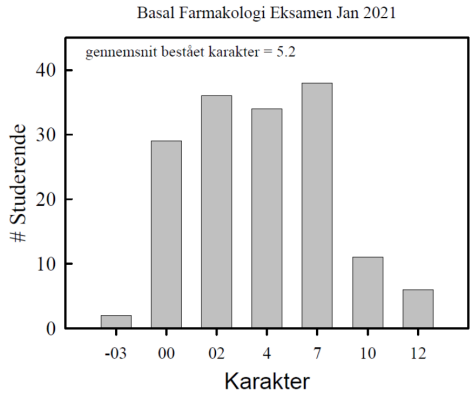


Fig. 6.5. Ending exam, average passing grade 5.25, 20% failed.

As an overall the students did relatively as usual, and with a specific look at the exam questions related to my lecture, they had an average mark of 2.9 (out of 5) which isn't great, but reflects the overall mark of the whole course (My exam questions are attached as a supplement).

Colleague 2: *I am especially wondering if PBL works if non of the students are prepared. Could an alternative be to included the 15 minute video in the beginning of the lecture before a discussion.*

I think this is definitely an option, yet I don't want to take the 15 minutes from the lecture and use it on something generic. I had a discussion with my teaching supervisor about this, here an alternative strategy was suggested. Where students were quizzed immediately in the start of the class in relation to the video so that students became aware of the learning the video provided and also helped others to gain that knowledge in form of the quiz answers. There could be other options, but the overall thought is to provide a carrot for preparing.

Conclusion

In conclusion, problem base learning can be used, also in large online settings with 100+ students. However it is not without problems of its own. One inherent problem is changing the culture of the way the students prepare for a lecture and how the teachers prepare for their lecture, this can be

done but require an cultural change from the beginning. Secondly, student wellbeing should be in the mind of the teacher, as some students found it anxiety provoking to participate in breakout sessions with "strangers", as other students in big courses are like strangers to them. Yet I do think it is a great tool and I will develop more of these sessions in the future.

References

Norman, G., & Schmidt, H. G. (1992). The psychological basis of problem-based learning: A review of the evidence. *Academic medicine*, *67*(9), 557–565.

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Yang, X., Chen, S., Ma, C., Fan, X., Song, J., Pan, Y., & Tang, X. (2020). Application of a novel teaching model integrating multiple teaching methods in periodontology education for chinese undergraduates, 1–17.

A Homepage

Exam questions and anservs (in Danish only)

5-Hydroxytryptamine

1.1 Nævn de 3 hoved organer hvor 5-HT er involveret.

Svar: Hjerne, Hjerte og Tarm

1.2 Gør rede for hvorledes 5-HT bliver produceret, samt forskellen mellem syntesen i hjernen og i kroppen?

Svar:

1. *Fra aminosyren Tryptophan (TP), der kommer fra mad.*
2. *Tryptophan hydroxylase (TPH) enzymet laver 5-Hydroxytryptophan (5-HTP).*
3. *L-Aromatic acid decarboxylase(også kaldet dopa decarboxylase) laver 5-Hydroxytryptamin (5-HT).*
4. *5-HT kan ikke passere blod-hjerne barrieren, derfor produceres 5-HT lokalt i hjernen. Her er det det enzymet TPH-2 der laver 5-HTP. I Kroppen er det enzymet TPH-1.*

1.3 Hvilke typer af receptorer findes der for 5-HT?

Svar:

1. Der findes 14 forskellige type, inddelt i 7 hovedgrupper.
2. De fleste er GPCR receptorer af alle typer, Gi, Gs og Gq koblede.
3. 5-HT3 er en ion kanal

1.4 Hvad dækker forkortelsen SSRI over?

Svar: Selective Serotonin Reuptake Inhibitor hvilket er betegnelsen for en række stoffer med antidepressive effekt.