Updating the Current Student Activating Activities in Basic Pharmacology Towards Alignment with new Learning Objectives and Problem-based Learning

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Background and motivation

Course Context and Facts

The course in basic pharmacology is an obligatory 5th semester course for medical students at University of Copenhagen (UCPH). The course is structured around 19 lectures and corresponding 8 student activating teaching sessions (SAUs). Each SAU session (2x45 minutes) covers one lecture topic and runs in parallel for 12-13 classes, with a maximum of 24 students. The 19 lectures are covered by 7 assistant/associate or full professors and each SAU session is covered by 3-4 SAU teachers, typically assistant professors, or PhD students. In the autumn semester of 2023, a total of 22 persons were teaching in the course.

The curriculum for the course is centered around a list of pharmacological drugs. At the end of the course the students should know the mechanisms of action and the targets for each of these drugs (approximate 120 substances). Apart from this list the students are also recommended to read a set of chapters for each lecture in Rang and Dale's 'Pharmacology', tenth edition. The exam is a 4-hour written exam without aids; the exam is integrated for three courses that are weighted equally (basic pharmacology, immunology, and pathology).

Justification

I have identified a need for continuity between the single lecture topics and SAU classes, and especially a need for updating the SAU assignments to be more problem-based/case-based, as for example demonstrated by Christiansen and Olsen in *'Analysis and Design of Didactic Situations: a pharmaceutical example'* (2006). In line with course being redesigned to become 'Basic Pharmacology and Innovation in Medicine and Technology' for the new bachelor study-programme in medicine (effective 2024) where the current course will be more integrated with the clinic and include an entrepreneurial angle as well, its timely to start this process.

Description

I would like to analyze how to systematically align, update towards more student involvement, and prepare the current 8 SAUs topics for the new course.

As a test case I will update the lecture for pharmacodynamics and corresponding SAU1 assignment, and test (with peer-review from my department and UP supervisors) how my updates are working. I will ask the students after the SAU class how they perceived the level and structure of the new SAU1 assignment. Based on this I will produce a general set of guidelines for updating the set of 8 SAUs. The guidelines should include:

1. A common scheme for updating and specifying the learning objectives for each topic.
2. A set of recommendations for updating the SAU content to be more student centered and student activating.
3. A set of recommendations for preparing the on-boarding and off-boarding material for new SAU teachers that in the future will follow a class across all 8 topics in opposition to, as it is now, teaching one topic across many classes.

Specifying Learning Objectives for SAU1 – and Generalizing for All SAUs

From the current course description and specified learning outcomes (Appendix 1) I started with isolating the lines related to pharmacodynamics. In read I marked the action verb:

- **Explain** basic pharmacological concepts, including e.g. the receptor concept, agonism, antagonism, affinity, and dose-effect relationships.
- **Describe** basic pharmacodynamic concepts.
- **Explain** on a molecular basis the interactions between drugs and biomolecules.

The description of learning outcomes for the new study-programme effective 2024 is slightly more updated, albeit not finalized. The knowledge base is identical to the one described above; however, a competence is added:

- **Integrate** the basic understanding of drug action with use in the clinic on an informed basis.

The lecture on pharmacodynamics and corresponding SAU1 is introducing the basic concepts of drug action at the cellular level. The existent learning outcomes are therefore more centered around declarative knowledge (**explain, describe**) and less on functioning knowledge (Biggs, 2003). The competence description related to the new version of the course is lining up a competence (**integrate, use**) that would be required of the students after the end of the course – but could be 'trained' throughout the course, and potentially introduced already in the first SAU class.

In the process of preparing for the lecture in pharmacodynamics I inherited a set of slides. I used this set of slides in combination with the current learning outcomes as a foundation to identify *the most important topics* to cover. These topics should be expanded in more depth in the corresponding SAU assignment, ideally to give the students a deeper level of understanding that will allow them to eventually put the basic concepts taught in SAU1 into work.

In Figure 1 I have listed the topics I defined as the most important, the topics are organized according to the logic order they were presented at in the lecture. Following the guidelines for constructive alignment (Biggs, 2003) I then sought to identify at which level the topics should be understood by the students. In Figure 1 I used the revised version of blooms taxonomy (Appendix 2), to identify the level for each topic (3,4,5) – I finally selected action verbs that I found suited to describe what the students should by doing *in action* to achieve the specific level of learning.

Mastery level	Remember	Understand	Apply	Analyze	Evaluate	Create
Most important topic, lecture and SAU1						
1. Four main classes of drug targets	List Describe Label					
2. Four main types of receptors and their signaling pathway	List Locate Describe Label	Classify Summarize				
3. Affinity of ligand binding (KD)		Explain Interpret	Plot/Graph Relate Compute			
4. Dose-response (D/S) relationship Efficacy and potency		Explain Interpret	Read off Relate			
5. D/S curves agonists: Fuld, partial and invers		Explain Interpret	Graph Sketch			
6. Different ligands: antagonists Competitive and non-competitive		Explain Interpret	Graph Sketch			
7. The effect of combinations of ligands - ligands having an antagonizing effect on the agonist			Hypothesize	Analyze Evaluate		
8. Processes that terminate the effect of drugs: Desensitization, tolerance and resistance.	List Describe	Classify Organize				

Fig. 1. In the lecture and corresponding SAU1 the students should learn the topics 1-8.

I then wrote an overall goal for the SAU1 (Yale Center for Teaching and Learning, 2023) as well as a list of concrete learning objectives covering the content of Figure 1.

Goal. Students should build up a toolbox of basic pharmacological concepts that they should use for comparing the pharmacodynamic profile of different drugs, and to assess the effect of combinations of drugs at the cellular level.

Specific learning objectives. After attending the lecture (F4) and finalizing the ***full*** set of SAU1 assignments

- Students should be able to **describe** the main classes of receptor drug targets and their mechanism of action, and

classify these according to the cellular timescale of activation/deactivation. (covering topics 1-2 in Figure 1).

- Students should be able to **list** processes that terminate the effect of drugs, and to **classify** these according to the timescale of the effect (covering topic 8 in Figure 1).
- Students should be able to **determine** (plot and read off data) dissociation constants and **compare** drugs with different affinity (covering topic 3 in Figure 1).
- Students should be able to **sketch/illustrate/plot** the dose response relationship for the main ligand types (full, partial, and inverse agonist) and **distinguish** their biological effect (covering topic 4-5 in Figure 1).
- Students should be able to **sketch/illustrate** the effect of antagonists (competitive and non-competitive) on the agonist D/S relationship, and **analyze** the underlying molecular mechanisms (covering topic 7 in Figure 1).
- Students should be able to **evaluate**, at the molecular and cellular level, the effect of combinations of drugs and **integrate** this knowledge with a patient case (attempt to build up competences that would eventually meet the overall course learning outcome).

I have focused on making the learning outcomes:
S – Specific
M – Measurable (see comment below)
A – Achievable (marked with bold above)
R – Result Oriented (marked with bold above)
T – Time bound (see first sentence)

Good learning objectives should be measurable or observable – and I judge that all these learning objectives are in principle. In the current layout of the course – it is the responsibility of the SAU teacher to provide a through walkthrough of the assignment with the students in the 2x45 minutes, and after the end of all the SAU classes, provide the answers for the assignment (uploaded on Absalon) in a format that the students on their own can work with the assignment and consult the correct answers. The level of individual/personal feedback is therefore very limited. In the

new course the goal is that one teacher follows a class through all the SAU topics, and I hope this new format might allow for more direct feedback to the students. The design of the exam, as it is currently, is solely a test of declarative knowledge. If the assessment at the end of the course should match the competences listed in the course description of learning outcomes, the exam form must be changed or include assessments on the required competences – suggestions for this kind of assessment could be case studies / group-based assignments and peer review activities (Cornell Center for Teaching and Innovation, 2023).

General scheme for updating SAU specific learning objectives, and for making the content of the SAU assignments specific:

A. From the lecture material list key topics and identify/choose the most important – these should form the base of the SAU assignment.
B. Use blooms revised taxonomy (Appendix 2) to assess which level the different topics should be mastered by the students.
C. Find appropriate action-verbs that can help identify which skills the students should use/practice in the SAU assignment to learn each topic.
D. Write the actual learning objectives, check that they are specific, measurable, achievable and result oriented as well as time bound.
E. Review the specific learning objectives you have made and compare with the overall course learning objectives – identify which of the topics are reaching the highest taxonomy level and use this topic to integrate with a case/problem.

Updating the SAU Assignment

Using the specific SAU1 learning objectives above I collaborated with a colleague on the redesign of the existing SAU1 assignment. After teaching the old assignment in Spring 2023 we identified some general requirements that we agreed would improve the level of student activation and participation in the SAU classes:

I. General pharmacological and chemical principles should be introduced using a concreate receptor system and actual drug used to treat patients – and mentioned on the curriculum drug list (see Context section).
II. The assignment should be framed by a case problem to spark the student's curiosity and to provide the notion of this curriculum being relevant in the student's future career in the clinic (Christiansen & Olsen, 2006).
III. The students should work with/use/analyze 'real' data and plot/sketch/determine/read off/calculate measures describing the pharmacological parameters of a drug in opposition to simply discussing/explaining/defining which tends to have a lower level of taxonomy (Cornell Center for Teaching and Innovation, 2023).

We chose a receptor system that constitutes an important drug target covered in several other lectures during the course, in the hope that the students would recognize and remember parts of SAU1 at later stages of the course. This receptor system also serves as a target for a broad range of drugs from the curriculum list of drugs (see context section), and in this way we ensure that the students will be working actively with this list from the beginning of the course.

We used this system to introduce all the required ligand types and asked the students to plot dose-response curves, read off and extract pharmacological measures that they should use to compare the different drugs. We framed the assignment with a case, where a patient needed treatment with one of the key drugs the students had been actively characterizing. We also expanded the case, to a situation where treatment of two drugs would potentially counteract each other and asked the students to analyze why. In this part of the assignment, we managed to reach the analyze level of the blooms taxonomy and get to a point where the students needed to use and combine different parts of the knowledge they had been taught.

I ran 4 sessions (2x45 minutes each) testing the new assignment. From my department and UP supervisor I learned that all the student groups generally worked focused throughout the 2x45 minutes, and that I created a safe learning space, with a clear structure. From the students I

learned that the level of the new assignment was adequate – none of the students I managed to ask expressed that the level was too low. My impression from running the 4 sessions was that the questions related to the case, and to working with the more problem-based parts of the assignments generated most questions and thoughtful suggestions from the students.

I also learned that the assignment in general was too comprehensive – in none of the 4 sessions we managed to get to the assignments dealing with learning objectives 1 and 2 – however we focused on objectives 4-6 which are the objectives that require most of the students, have the highest taxonomy level, and where a walkthrough of the assignment is most beneficial. Some groups were more efficient than others, and having a problem set that is too long allowed for individual groups, to keep working in the event that they are faster, or more prepared, than the average students.

Common scheme for making the assignment more student activating:

A. Use the specific learning objectives for the SAU and focus on the action verbs chosen.
B. Use concrete examples and substances from the drug list to introduce basic and generalizing concepts.
C. Convert assignments where students are asked to remember/discuss/explain/define to active assignments by asking the students to e.g. calculate, sketch, plot, compare, extract, solve and in this way have the students *work* with the curriculum.
D. Use a case to frame the SAU and to bring clinical relevance to the students. The case could be chosen from the topic that has the highest taxonomy in the specific learning objectives.

On and Off Boarding

Before introducing the new assignment, we set up a joint meeting with our colleagues teaching SAU1, this year we were a total of 4 teachers. We introduced the new assignment and each of us worked individually on solving the problem set. With feedback from everyone, I then composed a comprehensive written assignment answer that should serve

as a starting material for new SAU teachers, as well as a brush-up for the reoccurring teachers in the coming semesters. This process was helpful as it revealed which parts of the assignment that need more clear questions and instructions.

After running the 12 SAU1 sessions (each session 2x45min) we met again to discuss which parts of the assignment worked, which tented to be redundant, and which parts we could cut out – as we all experienced being short of time. I would recommend these two meeting to be obligatory for each SAU team, as that they could serve as an integrated part of continuedly improving the teaching and for welcoming new teachers in the teams. They should also be a forum for discussing new ideas, difficulties in the assignments and questions raised by the students.

For onboarding new teachers, I suggest:

A. Relaying the specific learning objectives of the SAU to the new teacher.
B. Making a written SAU assignment answer supporting the actual problem set.
C. Joint teacher meetings before and after the 12 SAU classes.

I also recommend producing a set of guides on how to structure the SAU classes, these could entail advice like:

A. Form groups and level expectations on how the students should participate.
B. Make sure to create a clear structure and ensure that there will be no call-outs.
C. Set aside time for the students to work actively with the assignments and with discussing the results, e.g by organizing that the students take turns to present what they arrived at in each sub-question.

For the new course I also suggest a general discussion of the expected level of preparation before the SAU classes. As the course is run now there is no expectation of preparation, only that the students have followed the lecture. Indeed, if the students had worked, to some extent, with the assignments before the SAU class the time could be spend differently, e.g. on more complex problems or cases.

Discussion of Outcomes and Improvements

The process of narrowing down the most important parts of the curriculum and creating learning objectives is time-consuming, but in my experience very helpful for narrowing down how to update the SAU assignment towards being more student centered and include more case-based content. The more specific these objectives are the better. Specific objectives make it easier to create new updated content, to onboard new teachers as well as relaying what is expected from the students after full participation in the lecture and corresponding SAU.

The work related to updating the SAU assignment can be split up in two interconnected tasks, a) updating the actual assignment material and b) setting up a structure for the 2x45 minutes, both of which should strive to create the highest level of student involvement, participation, and student-centered learning.

For the content of the assignment, I had a clear impression that the students worked actively with extracting information (plotting, normalizing, sketching) and I also had the impression that they really wanted to work with the more 'case related' questions. In the future I would like to work even more towards cased based learning.

For the structure of the SAU class I am convinced that group work, and insisting on forming groups, will activate most students, and in this way it will also be helping as many students as possible through the assignment tasks. I was happy to hear from my UP supervisors that I created a safe learning space. Next time I would like to test how the walkthrough of the assignments can become more dynamic and test how to get the individual groups even more activated in the review and feedback of the assignments. One way to achieve both more case based learning and dynamic walkthrough/feedback would be to have 3 different cases, that the students should work with in groups and present to each other. In such setup the students are the key responsible for relaying the curriculum to their peers, and I foresee that this would create more ownership and involvement.

References

Christiansen & Olsen (2006): Analyse og design af didaktiske situationer. English translation. MONA, 3. 7-23

Biggs, J. "Aligning teaching and assessment to curriculum objectives." Imaginative Curriculum Project, LTSN Generic Centre 12 (2003)

Cornell Center for Teaching and Innovation (2023):
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Anderson, L.W., & Krathwohl, D.R. (Eds.) (2001). A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives. New York: Longman (2001)

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Appendix 1.

Current course description incl. overall learning objective.

SMEB12022U Course in basic pharmacology

Year 2023/2024

FOLD THEM ALL IN

English title

Course in Basic Pharmacology

Education

The bachelor's degree in medicine - the course is not compulsory

Course content

The course must give the student knowledge of and understanding of basic pharmacological concepts, including pharmacodynamic and pharmacokinetic concepts. The student must also be able to explain the molecular basis for drug effects, dose-effect relationships, and based on larger drug groups, explain effects, use, side effects and drug interactions.

Target descriptions

After completing the course, the student is expected to be able to:

- Explain basic pharmacological concepts, including e.g. the receptor concept, agonism, antagonism, affinity and dose-effect relationships
- Explain basic principles in drug discovery and development
- Describe basic pharmacodynamic and pharmacokinetic concepts
- Explain drug absorption, molecular mechanisms of action, effect in the body, metabolism and separation, as well as the importance of genetic variation for these processes
- Explain on a molecular basis interactions between drugs and biomolecules
- Describe basic toxicological concepts within general toxicology
- Explain mechanisms of action, use, side effects and interactions for selected major drug groups.

Teaching method

Lectures and student-activating team teaching

Remarks

The course is evaluated in an integrated exam in immunology, basic pathology and basic pharmacology.

Work load

Category	Hours
Classes	19
Team teaching	16
Preparation (estimated)	55
Total	90

Feedback form

Collective

Registration

Self-service on KUnet
The course is not offered to external students.

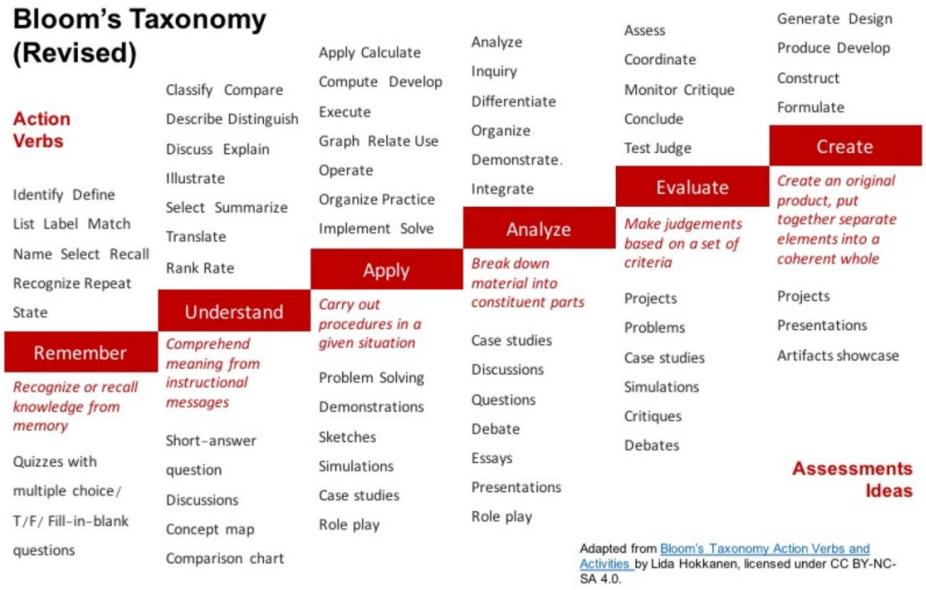
Examination

Point	0 ECTS
Sample form	Other things
Sample form details	No sample
Form of assessment	No rating
Censorship form	No external censorship

Criteria for assessment
No sample

Appendix 2. Blooms revised taxonomy.

Boston college, The Center for Teaching Excellence.
https://cteresources.bc.edu/documentation/learning-objectives/



Cornell Center for teaching and Innovation:
https://teaching.cornell.edu/resource/getting-started-writing-learning-outcomes

Bloom's Taxonomy of Educational Objectives

Level of Thinking	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation
A Few Action Words for Outcomes	Copy					
	Define		Apply		Arrange	Appraise
	Describe	Associate	Calculate	Analyze	Assemble	Argue
	Examine	Classify	Change	Appraise	Collect	Assess
	Identify	Contrast	Choose	Categorize	Comply	Choose
	Label	Convert	Construct	Compare	Create	Compare
	List	Demonstrate	Dramatize	Contrast	Design	Conclude
	Locate	Describe	Discover	Debate	Devise	Estimate
	Match	Discuss	Experiment	Diagram	Formulate	Evaluate
	Memorize	Explain	Illustrate	Examine	Manage	Interpret
	Name	Extend	Manipulate	Experiment	Organize	Judge
	Recall	Interpret	Modify	Inspect	Plan	Measure
	Recognize	Paraphrase	Sketch	Question	Prepare	Rate
	Reproduce	Predict	Solve	Test	Propose	Revise
	Select		Use		Setup	Select
	State					