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Applying real life examples for improved learning outcomes

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Aim

The aim of this project was to redesign and optimize a classroom lesson within the course "Drug Formulation" for BSc students in pharmacy by applying a 'problem to solve' teaching style in order to improve the students ability to apply and crosslink their knowledge about pharmaceutical formulations, i.e. support deeper learning and understanding rather than memory.

Background

Pharmacy is a study program that educates students towards professionals to deal with the scientific and social challenges around medication today and in the future. It is divided in several different subjects that are taught in parallel, just as the course "Drug Formulation", in which I am teaching one classroom lesson four times each to a reduced student size of approx. 10 students.

The course "Drug Formulations" is placed in the 5th semester and is divided into 27 auditorium lectures and 15 classroom lessons taught by numerous teachers that are responsible for their parts of the course. The intended learning objectives (ILOs) cover a broad range of topics within pharmaceutical technology including physico-chemical and biopharmaceutical properties of drugs, excipients in drug formulations, as well as the influence of the drug delivery system on bioavailability. The course "Drug Formulation" gives the students the theoretical background for their bachelor

project in the 6th semester and provides the fundamental basis for subsequent courses in the MSc in Pharmaceutical Sciences. Thus, it is of crucial importance that BSc students early on obtain basic understanding and essential knowledge in this field of study.

According to (Biggs & Tang 2011*b*, p. 91-94), there are two kinds of knowledge that can be taught. Declarative knowledge is pure knowledge that is memorized, e.g. knowledge that can be found in books, libraries etc. *Functional knowledge* on the other hand is performing understanding of the pre-received knowledge. It is 'real' understanding of concepts and being able to interact thoughtfully with the knowledge to solve a professional problem or manage a task. In order to obtain a 'professional' knowledge, both forms are complimentary as deep understanding of theory and application is the bases of functional knowlegde.

Within the course "Drug Formulations", the auditorium lectures are intended to provide the declarative knowledge, whereas the classroom lessons try to introduce some functional knowledge on particular examples. The classroom lessons deal with an assignment comprising a set of questions in order to show the students how *one* specific drug is formulated into its drug formulation. For this purpose, the students get the assignments beforehand and relevant literature references, which is the basis of their preparation for the classroom lesson.

I took over the one of the classroom lessons in 2013, which means that in this project it is the second time I am teaching it. In the first round, I also took over the "old-fashioned" set up of how the class used to be taught. The students were divided in small groups (3-4 students) in the beginning, in which they were able to discuss each question for a short time using the information from the supplied literature and their theoretical background from the auditorium lectures. Afterwards their findings were evaluated briefly in the whole class before moving on to the next question in a similar fashion. My task as a teacher was to guide the students through the question and help them where needed to find the right answer to the respective task. When taking over the class and teaching style, I quickly discovered that the assignment merely gave the impression that 'finding the answer to a question' is the key to knowledge rather than why is this knowledge important and what can it be used for. Therefore, I found that the 'old system' showed some obvious drawbacks, e.g.:

- Students that did not prepare for the lesson usually did not participate in the discussions, but rather where there to be taught the answers to the question.
- In the evaluation phase, usually only individual students from each group contirbuted to the discussion, whereas the rest of the group remained silent.
- Students that were well prepared and already solved most of the tasks at home were not interested in seeing a repetition of what they did at home.
- The 'find the answer' model does not promote deep learning or create functional knowledge, as it does not put the knowledge into relevant context.
- Students might perceive the knowledge as irrelevant which enforces surface learning.

Going back to the overall ILOs, the students are supposed to gain a big background knowledge on the basic theory, techniques and methods behind drug formulations, and furthermore obtain deeper understanding on how to correlate this knowledge to unknown scenarios. Generally, these ILO's are also in line of what I expect from the students passing this course. Especially with respect to declarative knowledge, the ILOs are also met to a high degree. However, in my experience from teaching in the Bachelor project (6^{th} semester), where students get an individually assigned task to solve on their own, the functional knowledge has not been previously obtained. It appears that during their BSc project, it is the first time that the students are confronted with real life situations and that they have to deal with problems that requires them to apply and cross-link their knowledge in a functional way. It is obvious that the current model of the course is not entirely optimal because students did not learn the required skills for a self-driven BSc project beforehand. I certainly believe that these skills are of crucial importance and should be and can be fostered early on already during the course "Drug Fromulation" in the 5^{th} semester. Students need to face problem situations and need to reflect and interact actively with these situations in order to enforce deep learning. These can be introduced for example in the classroom lessons.

Strategy and Methods

Rather than guiding the students through a set of questions related on a very theoretical basis in a 'finding-the-answer' fashion, one could set the assignment into a relevant context and let the students deal with a 'problem-to-solve' task. The students would learn to actively use their theoretical background in order to solve the problems. Compared to the 'find-the-answer' approach, I strongly believe that the 'problem to-solve' approach will improve the students' ability to apply their knowledge. Therefore, the aim of my project is to use this approach to my classroom teaching.

This concept is part of the theory of didactic situations (TDS) (Christiansen & Olsen 2006). TDS means creating meaningful examples that the students might actually be confronted with in their future professional life. This will catch the interest of the students and makes them aware of the importance of the subject. The term for creating such an artifical scenario in a lesson is called a 'didactic environment'. There are two things to consider. First the knowledge that is needed to solve the tasks in the assignment needs to be personalised. A situation needs to be created that is relevant to the students personal experience and knowledge, in order for them to adapt to the environment. And second, the knowledge the students learn needs to be (re)discovered, i.e. based on the student's own construction.

When planing the redesign of the lesson, I started to go through the written assignment and the material intended for preparation at home. Since the material was already handed over to the students at the start of the semester, I was not able to modify the written assignment. Fortunately, the assignment itself was written in a way that it actually could be used in the 'problem-to-solve' teaching style. The only downside of the assignment was that it did not reveal the relevance of the knowledge behind each question with respect to pharmaceutical formulations. Therefore, it was setting the assignment into the right context, i.e. change the way I used to teach it. However, not changing the assignment was in fact beneficial, as I was now able to run the old 'find-the-answer' teaching style in a comparative experiment with the 'problem-to-solve' approach. As mentioned above, I was teaching the same classroom lesson four times to a reduced number of approx. 10 students. Thus, I decided to teach one of the lessons in the old 'find-the-answer' fashion and compare it to three lessons applying the new 'problem-to-solve' approach.

The next step then, was to create a realistic and meaningful didactic environment that the students can relate to. Therefore, I decided to tell

the students in the beginning of the lesson that we will play a little mind game where they are now part of a pharmaceutical company that recently developed a new drug (in my case morphine). They are employed as pharmaceutical scientists and were asked to formulate this drug and all they got is the information from the preparation material. What information is important and what do they have to consider in order to end up with a successful pharmaceutical product? Therefore, the scene of the lessons in the 'problem-to-solve' approach was according to the principle: If the aim is to make a pharmaceutical formulation with morphin, then making the formulation from scratch is the obvious teaching/learning activity, under the appropriate didactic environment in the classroom lesson (Biggs & Tang 2011*b*, p. 179).

Finally, I modified the teaching style. Even though the old style had some pedagogic parts I liked, e.g. the group work, I was not entirely happy with the current setup, e.g. the drawbacks listed above. Therefore, I changed it to a 'lively and open' discussion amongst the *whole* class. I wanted to achieve that *all* the students are part of the developing discussion. All the students need to be part of the process where they rediscover their knowledge, i.e. the relevance behind the each question for the final formulation. Since I was afraid that the developing discussion would cease when debating each question one by one, I also decided to let go from this apporach. Instead, the evolving discussion will supply them with the answers to each specific question along the way as the knowledge behind it is interconnected.

My role in the lesson was to guide the students through the discussion, keeping it alive, and keeping them on track, so that they do not drift to far away from the assignment. Thereby, I was able to adjust each discussion according to the needs among the students. Depending on which points the students raised, different pathways towards the answers could be followed. For this purpose, I wrote a 'manuscript' with potential questions from my end to keep the discussion active (Appendix A). Before I gave the first lesson I studied this manuscript.

In order to assess the lessons, I handed out a class assessment form (Appendix B), where the students were able to evaluate the classroom lesson and its format, but also write down their perception of their learning. The assessment form was divided into a quantitative (Appendix B, points 1-4) and qualitative part (points 5-7). Furthermore, I was talking to individual students afterwards in order to get a more personal feedback.

Assessment

All four lessons ran very smoothly and I perceived the students activity and interest in the lesson as generally similar and positive. This was also reflected in the feedback from the student assessment form (Appendix C). Applying either teaching style, the students found the lessons to be similar in diversity, niveau, exam relevance and clarity of the ILOs. Furthermore, the students were well prepared and according to their own estimation learned new knowledge to a similar degree (4.6 out of 6 in both teaching styles). This was expected to some degree as my clear aim in teaching both styles was to fullfill the same ILOs.

The evaluation of the assessment form however, revealed also some differences such as in the students perception of the lesson. The 'problem-to-solve' approach was perceived much more interesting (5.5 out of 6) compared to the 'find-the-answer' approach (4.7). This was not surprising as it was my intention to increase the students interest in the subject by applying TDS. It was further confirmed when aksing individual students after the lesson about how they think this teaching style was and how it was compared to other classroom lessons. It became obvious that the 'answer-the-question' approach was what they expected from a classroom lesson as it was "Compareable to other klassetimer". On the other hand, the 'problem-to-solve' approach resulted in a much more positive feedback:

- "It was really funny and easy to follow"
- "Actually, I prefer this way of teaching, it gives more relevance to the subject"

Furthermore, the students own impresson of how much they actively contributed to solve the tasks in the lesson was different in both systems. It appeared that the students thought to be less active in the 'problem-to-solve' teaching style (3.9 out of 6 compared to 4.4). This might be explainable by the new teaching style. An open discussion in the whole class could scare 'shy' students or students that are not very well prepared from participating actively in the dialogue. Especially shy students rather work in smaller groups with their 'friends' where they dare to share their opinion. Furthermore, the risk with such an approach is that a few very motivated might run the show, giving no time or space for the more quiet students to contribute. When changing the teaching style, I was aware of this problem and thus, tried to activate the more quiet students throughout the lesson and involve them in the process. Thus, the result turned out to be still very

positive (3.9) in the 'problem-to-solve' approach, but leaves space for improvement. When interviewing some individuals after the lessons, they also pointed towards the involvement of quiet students in the discussion:

- "Group discussions in some cases would be good. Then the silence of some students might disappear"
- "It would be good to place the students closer to each other in the classroom so that it is easier to discuss with them and keep them active"

Part of the qualitative assessment was to observe whether the students have learned something in the lessons (Appendix B, point 5). The answers written for both teaching styles covered a wide spectrum of what was mentioned in the lesson but mainly in very broad terms. There was no description of the theories or knowledge behind these terms. Thus, it was difficult for me to evaluate these and draw a reasonable conclusion. However, it was interesting to read that students supplied very different subtopics of the lesson, meaning that a broad area was covered. In a future assessment form, I would modify point 5 to a more concrete task that can better be evaluated.

The students were moreover asked to mention those things that were best and worst in the assignment (Appendix B, point 6 and 7). The supplied responses gave a very interesting but also motivating and confirmative result. Thus, the feedback in the 'find-the-answer' lesson was very reserved and concentrated on the structure and content of the lesson:

- "Clear and structured way through the questions"
- "To think more in a chemical way"
- "I didn't know more to begin with when I came"

It was clear that the students had not much to add to a system they were used to, but they valued the structure of the lesson as it sticks close to the assignment. Furthermore, students seemed to have perceived the assignment as pure repetition from the declarative knowledge they get from the lectures and thus, found it less interesting.

On the other hand, there was an extensive feedback from the students taught in the 'problem-to-solve' style. This might be due to the fact that the students were facing a new way of teaching. Generally, they found the 'problem-to-solve' approach very interesting, but also wrote that they learned a lot of new things. It was obvious that the students were very glad that they were able to apply their knowledge to a relevant situation:

- "Many good facts, learned a lot"
- "The opportunity to discuss in class"

- "You better learn a system when you actually use it"
- "The teacher was very active, and this caught our attention"
- "That we were able to explore a drug molecule and decide ourselves how we would formulate it"
- "The flow in the dialog in which the assignment was performed, and not the slavery like way through the single questions"
- "That we were challanged"

Overall, I got the impression that the students were pleased by the open discussion and the freedom to decide (with some guidance from my end). This was reflected in a very lively dialog in these lessons, that most of the students participated in. From the feedback, I conclude that it is very likely that my aim of getting the students to rediscover their pre-existing knowledge was successful.

Despite the positive feedback, the 'problem-to-solve' lesson demonstrated one drawback. With the very open setup and dynamic flow, the students found it really hard to follow the questions in the assignment. It was hard for them to understand why the questions were given beforehand. The whole lesson was perceived a bit confusing as the answers were not supplied in the chronological order but rather as a result of the progressing discussion. Accordingly, it was mentioned in the assessment form but also during the student interviews. I suspected such criticism as I was unable to change the written assignment beforehand. Thus, my aim is to address this issue by redesigning the assignment in the future.

Overall, I want to finish with a quote from an interviewed student that summarizes the 'problem-to-solve' teaching style with its ups and downs, but pointing out the potential as a continuing teaching style in the classroom lessons of the course 'Drug Formulation': "It wasn't easy to follow where we were in the questions, but it was very interesting and had a dynamic flow".

Conclusion

In this project I have redesigned the teaching style of a classroom lesson applying TDS in order to increase deeper learning and create functional knowledge. My aim was that the students learn the concept, methods and principles of formulating a drug in the context of a 'realistic' didactic environment. I found it interesting to apply a (for me) new teaching style

and compare it to the one I previously used. I realized that reflecting over ones own teaching can introduce some very rewarding new elements and improve my teaching skills but also motivate students. I found that the redesigned course got a very motivating feedback, as students were very positive about being challenged in a way they experience their knowledge as meaningful. However, the students criticized that it was hard to follow the questions from the assignment. It can be concluded that applying TDS was beneficial for the students to adapt functional knowledge in the context of this classroom lesson.

Perspective

It was found that the teaching style was not aligned with the written assignment the student got beforehand. Obviously, this needs to be addressed in future as I am planing to keep the 'problem-to-solve' approach in my classroom lesson. Furthermore, it was pointed out that students do value work in small groups to some degree. Therefore, I would like to introduce group work again at relevant points of the discussion. This would also force more students into the discussion and thus, increase the students activity. For a better assessment, it would be good to get more actual student performance data (Appendix B, point 5), whether the lesson actually resulted in better learning outcomes.

A Manuscript for the 'problem-to-solve' lesson

1. Morphin
   - What pharmacological class of drug does it belong to?
   - What is its indication?
   - Strong pain, weak pain?
   - How would you according to its indication deliver it?
2. You are now working in a pharmaceutical company and are asked to make an as fast as possible oral delivery of the drug.
   - What do you need to consider first? → physico chemical properties
   - What are these properties and how are they defined?
3. Why are these relevant? because they influence the bioavailability
   - What is bioavailability?
   - What does Lipinskis rule of 5 tell us?
   - How is the BCS classification system defined and what does it tell us?
   - How does the phys-chem data of morphin help us to classify the drug? [→] Can be classified as BCS class 1 drug, i.e. high solubility and permeability
4. However, its oral bioavailability of Morphin is 20-40%
   - How can this low bioavailability be explained? Metabolism
   - What types of metabolism do you know?
   - Where does metabolism happen?
   - What is the reason for metabolism?
   - Which ways of excretion are possible?
5. How does metabolisation work
   - What chemical reactions can happen during metabolism?
   - How can a molecule be modified to prevent metabolism?
6. In a formulation morphin might also undergo degradation
   - What types of degradation do you know?
   - How can you prevent the molecule from degradation in your formulation?
   - What excipients can you include for this purpose in you formulation
7. We have the drug, prevented oxidation with an antioxidans, EDTA and nitrogen
   - What else do we need for an oral formulation?
   - What else do we need to consider in case of an intraveneous formulation?
   - What excipients can we use for these purposes?

B Class assessment form

1. How did you receive the Klassetime?

	1	2	3	4	5	6	
Unclear Learning objective	o	o	o	o	o	o	Clear learning objective
Monoton	o	o	o	o	o	o	Diverse
Too low niveau	o	o	o	o	o	o	Too high niveau
Not relevant	o	o	o	o	o	o	Exam relevant
Boring	o	o	o	o	o	o	Interesting

2. How much did you learn today?

	1	2	3	4	5	6	
Only little	o	o	o	o	o	o	Quite a lot

3. I tried actively to solve the tasks the teacher asked me to do

	1	2	3	4	5	6	
To low degree	o	o	o	o	o	o	To a high degree

4. How was your preparation for today's klassetime?

	1	2	3	4	5	6	
Unprepared	o	o	o	o	o	o	Well prepared

5. Name at least two things you learned in the klassetime today:

_____

_____

_____

6. What was best in the assignment?

_____

_____

_____

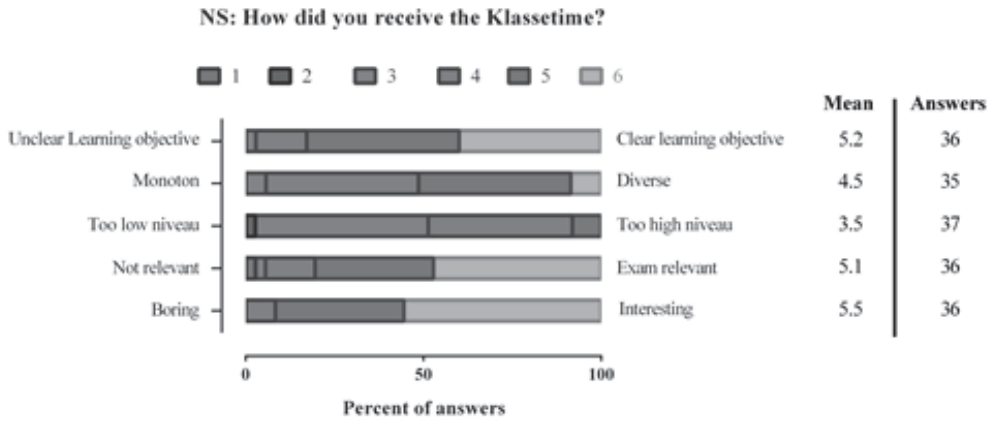
7. What was worst in the assignment?

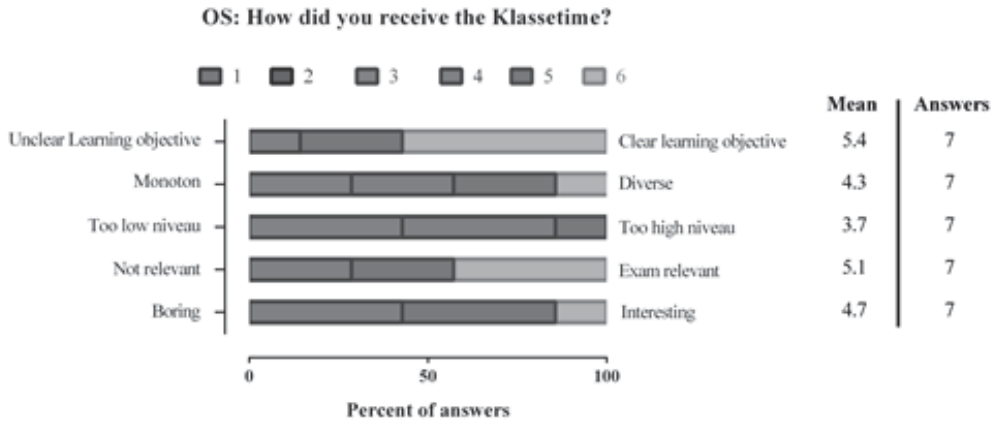
_____

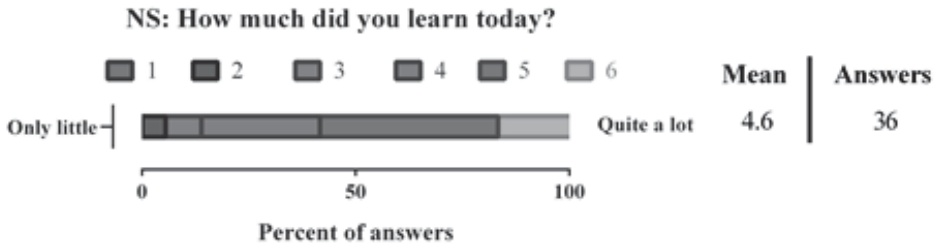
_____

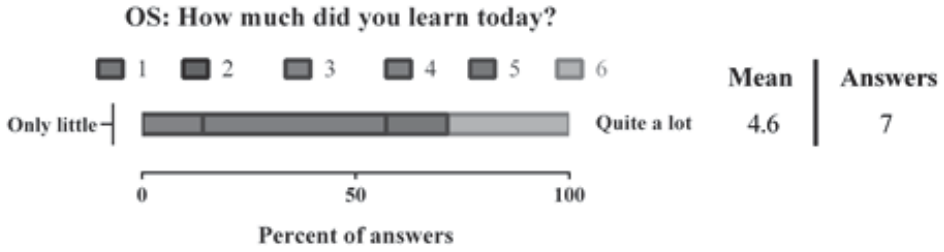
_____

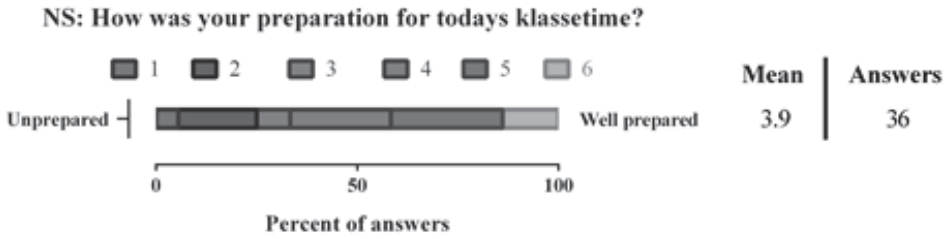
C Quantitative evaluation of the class assessment form (NS: new system, OS: old system)

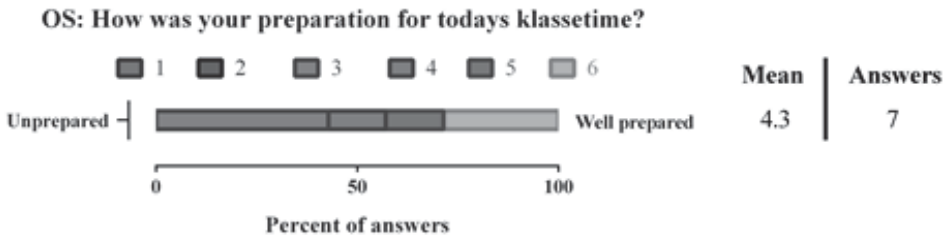


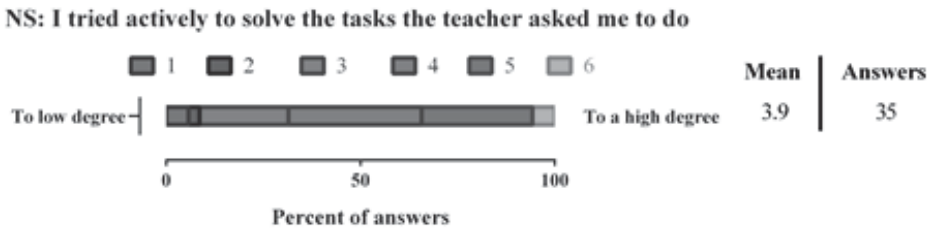


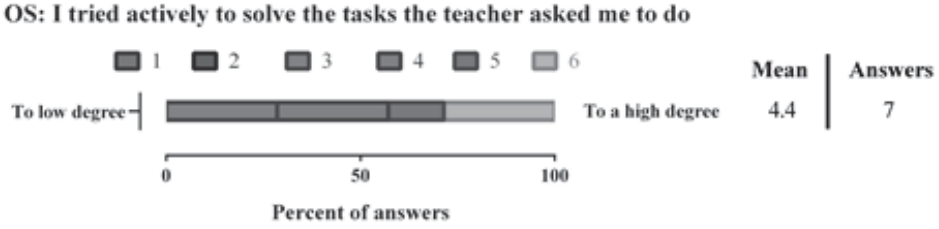












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