From parasite diagnostics to parasite control: Implementing inquiry-based learning

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General introduction

Inquiry-based learning approaches are built on the constructivist learning theories that the learner constructs his or her own learning through relevant learning activities (Biggs and Tang, 2011). Learning is not a passive transfer of knowledge from teacher to student, but is personal and constructed on already existing knowledge of the student (Rienecker et al. 2019). The inquiry-based approach is a pedagogical method promoting learning by guiding the student in the direction of solving a problem often from real-life (Wessel, 2013). Here the teacher's job is to guide the students with open questions and not give them direct answers. Inquiry-based learning can be represented as a cycle, where a Danish version of this cycle named the 6F-model (see Fig 1) has been developed at University of Copenhagen (Persson, 2013).

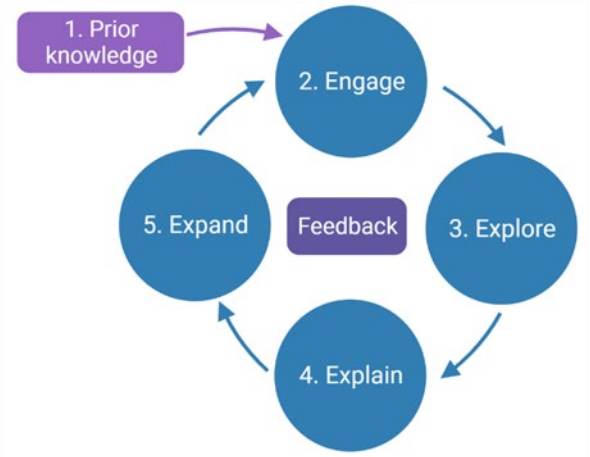

Fig 1. The didactical 6F-model. 1) First, establish what prior knowledge the students have, 2) get the students to be engaged in a topic and show interest (often by presenting real life problems), 3) the students explore and gather data

themselves, 4) the students share and explain results/conclusions with each other, and 5) the gained knowledge is expanded to other problems/topics. The feedback phase is not a fixed session in the cycle, but is continuously guiding the students round and round in the cycle. The figure is modified and translated from Frisdahl (2014).

Background

I conducted my intervention during the course 'Human Parasitology' (SBIK10200U). The course is anchored at IVH-SUND and is a restrictive elective course (7.5 ECTS) in block 2, offered in the fourth year of the MSc program in Biology. Students from other programs (i.e. Global Health and Animal Science) as well as international students can also be enrolled. The course has a maximum limit of 30 students, but typically enrolls 12-15 students.

Overall, the course is thematically structured according to the different groups of parasites relevant for human health. So for each parasite group the epidemiology, diagnosis, surveillance, and control is taught by leading experts in the field. This means that the teachers come from both SUND and SCIENCE at UCPH, and Statens Serum Institut (SSI), which is under the auspices of the Danish Ministry of Health.

Last year, I taught in the course for the first time on the topic 'Helminth parasite diagnostics' via zoom during the Covid pandemic. So this year, I was looking forward to carry out the practical laboratory exercise as part of my teaching since it is part of the 'parasite diagnostic'-topic. As preparation, I interviewed the course coordinator and it became evident that due to a change in available educators/staff some years ago the practical laboratory exercise had been replaced with class room lectures and videos for the students to watch themselves. I also looked through the teaching time plan from previous years (which is the plan shared with the students) and the topics closely linked to 'parasite diagnostics' was spread out with no clear indication of being taught in a logical order. From my interview with the course coordinator, my observation was confirmed and she explained to me that since many of the teachers are external/not in-house, they often only have a few time slots where they are available for doing the teaching. Therefore, some of topics are moved around in the teaching plan. Finally, I scrutinized the

student evaluations from the previous years and discovered that overall the students found the course quite lecture-heavy.

Goal of the intervention

My overall goal with the intervention is to strengthen the constructive alignment between three different course topics, which until now has been taught somewhat separately during the course. Specifically, I want to try an inquiry-based learning approach in all three course topics both separately, but also overall by teaching the three topics right after each other in a logical order. I hypothesize that this could help us move past the two quantitative levels of understanding in Biggs SOLO taxonomy (uni-structural and multi-structural), and create a learning environment where the students can demonstrate coherent understanding and apply concepts to a problem (Biggs and Tang, 2011; Rienecker et al. 2019).

Description of the inquiry-based learning activities

Three course topics from the course 'Human Parasitology' were merged into interconnected 1.5 days of teaching. The three course topics were: 1) 'Parasite diagnostics' (the topic I taught last year), 2) 'Parasite epidemiology', and 3) 'Parasite control'. The planning and implementation was inspired by Frisdahl (2014), essentially following the didactic 6F-model (see Fig 1).

The overall idea was that the students were asked to 'play the role' as a public health officer in Uganda, with the final task to decide which control actions should be taken against parasites in a village near Lake Victoria. To be able to do that, the students have to: 1) Diagnose the parasite infections in the human population, 2) Perform epidemiological calculations of the parasite prevalence and intensity in the population, and finally 3) Decide the control actions needed based on the previous two. This mimics what is done in reality in parasite endemic areas – and the task can be solved through guided steps and in collaboration with their student-peers.

Since the students come from different study programs and backgrounds, their prior knowledge (see Fig 1) is different (Rienecker et al. 2019). To accommodate for that I gave an introductory lecture on

general diagnostic methods in parasitology before moving on with the laboratory exercise. A detailed description of the activities is outlined in Table 1 (below).

Overall, the lab exercise was carried out as *structured inquiry* (Wessel, 2013), where I provided the problem (which parasite infections do the human population from the Ugandan village have and how big is the parasite burden?) and an outline for addressing the problem (the diagnostic method to use). Instead of providing the lab protocol for them to follow blindly, I gave the students a disassembled protocol (each step on separate paper-strips) for them to correctly order the steps. The protocol is easy, but the students need to grasp some basic principles in parasite transmission as well as the purpose of each protocol step to assemble correctly. The correct protocol was then demonstrated in the lab before the students worked on real fecal samples (pig fecal samples spiked with parasite eggs for safety reasons) themselves. The data produced during the lab-exercise were corresponding exactly to the data points missing from the excel data-sheet, the students downloaded from Absalon. The data generated by the students thus completed the data sheet which was then used in the next exercise.

The epidemiology exercise was implemented as *guided inquiry* (Wessel, 2013), where I provided some initial questions to get the students started on the calculations, but leaving room for students self-directed exploring of more questions/calculations. The students worked in groups and I was around and checked-in on each group. Some of the students expressed frustration during the exercise since I had not given lectures on topic 2 and 3, but I guided them with open questions and reminded them that all they needed was in the available material on Absalon.

The last part of my teaching on topic 3 was also implemented as *guided inquiry* (Wessel, 2013), but the students did the first steps as a homework assignment supported by provided reading questions and the available material on Absalon. The student groups were asked to prepare a small presentation for teaching day 2. The purpose of this homework assignment was to encourage metacognitive thinking (Biggs and Tang, 2011), since the questions (e.g. deciding the final control actions towards the parasites) required the students to integrate the knowledge gained

from the two previous exercises. The answers to these questions had no predefined right or wrong, but is more concerned with some overall concepts related to parasite epidemiology and control. Many different things can be discussed based on the provided questions and differs between e.g. parasite species and geographical regions.

Unfortunately, on teaching day 2 only one student showed up due to illness among the other students so I had to change the format to one-on-one where the student presented to me and I guided a discussion with open questions. I had my own calculations for the same dataset (the other parasites) which I discussed with the student to ensure that all the aspects were brought into discussion with the single student. I finalized with a lecture summarizing the most important things from topic 2 and 3 that the students had worked on themselves, like a flipped classroom.

Table 1. Detailed description of the specific teaching activities.

Teaching day 1		
Time	**Activity**	**Learning approach**
9.15-9.45	**Lecture (topic 1)**: 1) Initial 30 min-lecture on general diagnostic methods. The lecture ended with plenum discussion on pros/cons of the presented methods 2) Introduction to 'play the role' as health officers in Uganda.	Lecturing
10-12	**Laboratory exercise (topic 1):** 1) Instead of providing the lab protocol for the students to follow blindly, I gave the students a disassembled protocol (each step on separate paper-strips) for them to correctly order the steps. 2) I demonstrated the laboratory method (kato-katz diagnostic method) 3) Each student performed three slides, counted the parasite eggs under microscopes, and noted down sample-ID and egg count data.	Structured inquiry
13.15-14	**Follow-up on lab-exercise, and moving into topic 2:** 1) Follow-up on lab exercise, by using their newly acquired knowledge on diagnostics (theoretical	Guided plenum discussion

	and practical) I guided a discussion on method specificity/sensitivity in plenum. 2) Then students shared their data (from lab exercise) on the whiteboard, and variation in data was discussed, which naturally lead to questions related to topic 2.	
14.15-16	**Epidemiology exercise (topic 2):** 1) Students entered all the data (from lab exercise) in their own downloaded data-sheet (now a complete data set from 100 villagers) 2) Student groups was formed and each group selected one parasite species to focus on for the exercise. 3) Group work in the class room. I provided some initial questions to get the students started on the calculations, but leaving space for students self-directed exploring of more questions/calculations.	Structured/ guided inquiry
At home	**Student homework assignment (topic 2+3):** In the groups, the students were asked to work on the final task as health officers (the parasite control actions) based on the two exercises. I provided reading questions as guidance.	Guided inquiry and metacogniti on
Teaching day 2		
Time:	**Activity**	**Learning approach**
9.15-11	**Groups presentations (topic 2+3):** Instead of plenum presentation, I wanted to try another format where the students presented to each other in smaller groups. *However, all students but one was ill on the teaching day. So that single student presented for me and I asked open questions to start discussions*	Peer feedback
11-12	**Lecture (topic 2+3):** 20-min lecture on the most important points in parasite epidemiology and control as wrapping up the presentations.	Lecturing

Student conceptions and evaluation

After the teaching, I had a plenum session with students where they were asked to give feedback on the different activities during the 1.5 days of teaching (i.e. what worked well? What could be improved?).

Even though the students had different backgrounds the majority felt well-prepared to do the lab exercise, especially because of the lab demonstration I did, wrapping up the protocol-puzzle exercise. To work on real fecal samples (here from pigs) can be transgressive for some, but the students felt okay about it since I gave initial safety instructions. Furthermore, most students agreed that trying out a practical hands-on diagnostic method themselves was a very nice experience and helped them understand on a deeper level what parasite diagnostic is.

> "After trying the method myself, it is much easier to understand and remember what it takes to actually do the diagnosis." – student

> "We only worked on 3 samples each in the lab and that was a lot of work – now I can imagine how much work is put into the number samples often presented in the scientific papers we read." – student

Several students mentioned that, after doing the lab-exercise, they found it easier to understand the method section when reading scientific papers.

Most students liked the group work on epidemiological calculations using the data set on 100 individuals. They felt that the introduction to the calculation exercise and the time set aside was enough, and also had time to do most of the 'homework' assignment. Several students mentioned that trying out calculations themselves increased their understanding.

> "I really enjoyed the calculations and I love shuffling data around in excel." - student

However, one student felt very frustrated.

> "The data set was too large and I don't know how to use excel so I totally gave up. Much more guidance is needed for this exercise" - student

Here the different backgrounds and experiences of the students taking this course might be an issue to keep in mind. In my teaching, I only gave an initial short lecture to accommodate for the different student backgrounds prior to the first laboratory exercise. Perhaps I should spend more time on some of basic concepts if my teaching next year is scheduled early in the course. This could be helpful to the students feeling quite frustrated during the calculation exercise which was taught as guided inquiry.

Most students found the overall idea with 'play the role' as a health officer worked well. They all liked working with a real life problem-based situation where they could use their different backgrounds in the discussions.

> "It was fun to try to think as a health officer in a broader sense. It created coherence between the elements." – student

Peer feedback

I asked the course coordinator to comment on this essay and the main feedback was that my intervention had indeed created deeper learning for the students. The course coordinator had recently had a teaching session (with the same students on the same course) on a different topic. At this session the students were able to bring the knowledge they gained from my inquiry-based teaching into the discussions trying to solve new problems.

Conclusion and future perspectives

Transforming existing teaching into inquiry-based learning requires some effort, design and planning, and might not be suitable for all types of teaching. However, when it works (as I felt it did for my teaching) it is highly rewarding both for the teacher (I had so much fun teaching as a facilitator) and for the students. The peer feedback from the course coordinator about the students being able to apply concepts from my

inquiry-based teaching early in the course on new problems encountered later in the same course is a strong indication of deeper learning.

For future teaching in the course, the course coordinator has expressed an interest in trying to interconnect more topics and perhaps transform more of the teaching into inquiry-based teaching since the topics taught in 'human parasitology' is indeed real life problems for hundreds of million people worldwide. With the high number of external teachers, a first step could be to have pre-course teacher's meetings discussing to ensure that the effort is put into the appropriate topics with regards to teacher motivation and time available.

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