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TOWARDS INCREASED STUDENT PARTICIPATION IN A BIOLOGY UNDERGRADUATE LECTURE SERIES

Abschlussarbeit zur Erlangung des Diploms
in Hochschuldidaktik und Technologie in der Lehre

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Ich erkläre ehrenwörtlich, dass ich meine Abschlussarbeit selbständig und ohne unzulässige fremde Hilfe verfasst habe.

Abstract

Undergraduate teaching in the natural sciences is predominantly performed by using lecture series. Classically such lectures are overwhelmingly teacher-centric, they are often performed in large classrooms where a professor gives a presentation and the role of the students is essentially limited to listening and taking notes of the covered subjects. There is little interaction between teacher and students and the exchange is limited to the occasional question from either side. In addition, mostly textbook knowledge is covered during such sessions mainly because they are readily available and primary literature is complicated and often too detailed for such settings. Together this results in an overall passive student behavior, leads to practically no learning in the classroom and makes students hesitant to tackle primary literature. Unfortunately, this archaic way of lecturing continues to be used despite a large body of research promoting alternative teaching methods that can significantly increase the learning outcome under such conditions.

The goal of the present work was mainly twofold: to increase student participation in a lecture series as well as to incorporate primary literature. I report and reflect about my approach designed for an undergraduate lecture series in animal physiology at the University of Fribourg. To increase student participation, I used a live voting tool and formed small student groups that each had to give a presentation during class in front of their peers. This accomplished the goal that every student had to participate actively during the lecture in the course of the semester. The presentations were based on a primary literature article and thereby served the purpose to incorporate up-to-date research data into the classroom and to familiarize the students with primary literature. I analyze my experiences from these experiments both from the instructor and the student perspective.

In the end, I will quickly discuss a model, inspired by biological research, that suggests a possible way forward in how to more rapidly change the status quo of this type of current university teaching.

Table of contents

1. Introduction

Public universities are institutions that get a mandate by the government to perform two main functions: on one hand, they offer higher education and on the other hand they carry out research. The teaching side educates students and should prepare them for a successful start into their respective career. The research, often basic research, should advance knowledge that ultimately benefits the society by promoting developments and solving challenges. Both aspects, however, are often being performed by the same persons: university professors. And these two duties, teaching and doing research, get into conflict with each other as each professor has to allocate their limited time in order to find a good balance to fulfil his or her teaching duties as well as to advance their research. The individual successes in these two domains are difficult to compare. Research output can more easily be measured quantitatively, for example the number and type of research papers or citations is often used to judge the performance in that domain[1]. This is done both on an individual basis, for example by rankings published in journals[2] as well as on institutional levels, for example by one of the leading world university rankings by the Times Higher Education (THE)[3]. In addition, a great research output can result in international visibility and access to a lot more competitive grant money. Teaching performance is more difficult to evaluate and is also harder to compare across institutions and countries. If a professor is a great teacher will therefore mostly be known to his or her students but will generally have little consequence for their academic success. This imbalance of evaluation possibilities leads to a system where university professors might be hired almost exclusively due to their research vision and the assumption is that a good researcher will also do well in front of a class. In addition, later tenure and promotion decisions are evaluated on this incentive system and a good track record of research output is far more important than a beautifully taught introductory class. Therefore, spending additional time to prepare classroom content, or to apply innovative teaching methods, effectively penalizes people looking for academic

[1] There is much controversy in the validity of such quantitative measurements to create rankings but this is not discussed here (for example, see (Saisana et al., 2011)).
[2] https://www.laborjournal.de/rubric/ranking/
[3] https://www.timeshighereducation.com/world-university-rankings/

laurels. In the worst-case scenario, at least from an education point of view, this could lead to a situation where a professor spends as little time as possible on teaching.

These days universities are certainly aware of this issue and the importance of good teaching is being recognized. One possible reason is that in this new age of global competition, again due to the omnipresent university rankings and an ever easier spread of information, a good teaching reputation might actually attract above average students. Collectively this has led to the generation and promotion of guidelines and policies that support innovative teaching at many universities. In addition, student questionnaires are now being used on a regular basis to rate classes, courses are being offered to introduce and spread novel teaching approaches and teaching experience becomes more important in hiring and evaluation committees. Indeed, many universities have now put specialized centers in place to promote good teaching practices and to support and train their faculty in education, albeit for the moment these efforts are mostly on a voluntary level. But teaching is being discussed and also supported by the highest levels of university governments. For example, the University of Bern developed for its strategy 2021[4] four sub-strategies, one of which is focused on teaching and demands to implement innovative teaching and learning methods to reinforce the reputation as a teaching university. At several additional Swiss universities, similar efforts are also being supported financially and competitive money is made available for novel course designs and a diversification of teaching methods. If and how fast such efforts will result in better learning outcomes of the students should be evaluated on a continuing basis.

Despite difficulties in quantifying teaching performance there are efforts to assess and compare teaching across institutions. The Swiss education system is sometimes considered the best in the world[5], implying that the school system as a whole does very well. But how do individual Swiss universities perform in such teaching rankings? For example, the THE rankings place leading Swiss institutions like ETHZ, EPFL and UniBe as the overall 10th, 38th and 105th best university worldwide[6]. However, in terms

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[4] Strategie 2021, Universität Bern 2013
[5] WEF Global human capital report 2017
[6] www.timeshighereducation.com 2018
(Unfortunately, Switzerland is currently not part of the “THE: Europe teaching rankings” first published in 2018)

of teaching they rank on the 21st, 54th and 154th position respectively, all significantly below their overall ranking[6]. Maybe surprisingly, teaching actually amounts for 30% of the overall score and is based mostly on an international reputation survey and several student and degree ratios[6]. These lower teaching rankings, as compared to the overall university rankings, indicate that there is room for improvement in the teaching domain at Swiss universities.

1.1. Lecturing in the biology undergraduate classroom – a critical assessment

The way in which students are taught within a university setting can certainly vary significantly depending on the individual study program, the faculty and not least the instructors themselves. It is impossible for me to assess teaching overall in a representative or unbiased way. Nevertheless, studying in Basel, Lausanne and New York and teaching in New York, Fribourg and Bern does give me first hand impressions of classroom activities both nationally and internationally. I will therefore draw from these personal experiences in the natural sciences and especially biology, but I do believe that certain observations can be generalized also to other disciplinary settings.

Lecturing has been the predominant form of undergraduate teaching since many centuries and remains the main instructional style at universities. For example, during the first 4 semesters of the Bachelor of Biology at the University of Bern students spend 63 % of their class time attending lectures, 31 % in a lab setting doing experiments (which also includes lectures to introduce experiments for example) and 6 % doing exercises (also held in lecture rooms) (Table 1); and these numbers are likely similar in other places. In research universities, the percentage of time spent in lecture halls tends to become smaller in semesters 5 and 6 once students become more specialized and involved in actual research by joining individual labs for their research projects.

Table 1[7]: Overview of Biology undergraduate timetable in Bern

	hours per week					
Semester	**1**	**2**	**3**	**4**	**total**	**%**
Lecture	24.5	13	23	14	74.5	**63**
Practicals	-	19.5	7	10.5	37	**31**
Exercises	4	-	-	3	7	**6**

(Not considered are a few additional courses of choice, likely to be lectures as well.)

In the classic set-up of these introductory lectures a teacher stands in front of a class, sometimes with several hundred students, and introduces topic by topic on a weekly basis most often using projected slides. This approach to teaching has also been called "teaching by telling". The role of the students is usually limited to listening and note-taking, although occasional questions by the teacher and/or the students can lead to small discussions during class. Textbooks are often used in conjunction with such lecture series. Nowadays many instructors will also make their slides available to the students through the university learning platforms.

I would consider this method of teaching the standard approach; at the same time, there certainly is also a minority of instructors that uses additional elements, for example including the use of the black-board, encouraging additional discussions or solving problems in class, but for the moment I neglect these "outliers". Education specialists have been criticizing the above described standard approach of lecturing for many years now (National Research Council, 2015). They have shown that this way of teaching is neither very effective nor very supportive for the immediate learning of the students sitting in such classes. In addition, they have suggested and analyzed change strategies (Henderson et al., 2011) but their implementation lags behind. I would say these criticisms, as well as the putative solutions, essentially have not reached those educators who are not specialists in teaching and their teaching, lecturing that is, continues to be done the same way as many years ago.

I believe this outcome is mainly the result of the stereotypic career trajectory in the natural sciences. As outlined most of the professors got their initial job due to their research accomplishments but their new university appointment comes decorated with

[7] http://www.biology.unibe.ch

a teaching assignment. Now let's assume that the teaching assignment is a lecture series. On top of establishing an own research group, all of a sudden lectures will have to be prepared, requiring a significant time investment during the initial instalments. Since in general there is no formal teaching training required, the new faculty will most likely do something similar to what they have experienced in the past themselves: which was traditional lecturing. In principle, this is a reasonable approach as their own experience exemplifies a successful outcome and there is no a priori reason to believe it should not also work for the next generation of students. Unfortunately, one of the overlooked facts is that this approach only worked for a minority of the students that initially started studying together. For example, in the US only about 40 % of students starting to study natural sciences actually finish a degree in the natural sciences (Olson and Riordan, 2012). All remaining students, despite having initial interest in the subjects, left along the way to follow up other paths. Would other teaching methods maybe make a difference and retain more students?

While it is an open question of exactly how much past experiences shape the teaching of the current faculty, there is research showing that it can clearly have an influence (Oleson and Hora, 2014). Moreover, the opinion that the current lecturing approach works well can easily be reinforced, for example if the students do well on exams or if they positively evaluate some of the attended lecture series. Everything seems to be going well – but a comparison to another teaching approach is missing. It often remains unclear of how well students really understood the fundamental concepts they are studying. Good exam grades can be misleading in that they possibly represent good memorization. Comparing different lecture series will always rate some more positively than others but such good evaluations should not be taken as evidence that the teaching itself is necessarily done well. More ideally, one could assess if the studies resulted in the formation of a solid conceptual knowledge base, the ability to apply learned theories to novel tasks and a successful performance on the job. This of course is much more difficult to follow up and also not immediately measurable. But to simply teach the same way as oneself has been taught is a fundamentally poor justification for the chosen approach, as it ignores new developments that happened in the meantime and indeed would result in the prevalence of the status quo.

A large body of research in the field of pedagogy and education tries to identify, quantify and compare the variables that contribute positively to successful higher education. For example, John Hattie now lists and ranks 252 factors related to student achievement[8] in order to identify effective ones that work well in education. Research on higher education has clearly shown that shifting from a purely lecturing based system to different forms of active learning results in significantly better learning outcomes, as measured, for example, by the percentage of students passing exams (Freeman et al., 2014). Discipline-based education research suggests that more emphasis should be placed on engaging students during class time in order for them to better understand core scientific principles. This approach does not mean that traditional lectures should be abandoned, there are still good reasons to give lectures – but paired with using a modern way of lecturing. For example, lecturing can work well to motivate students, to give an overview of the subject or to simultaneously transfer information to a big group of students. But lectures should not try to cover every single piece of information because some of the basic knowledge that comes directly from the textbook can indeed be looked up there directly. Such an approach would then free up some time to do other activities, for example in-class exercises. For the current work, I wanted to experiment with tools that shift the teacher-centered lecture approach to a more student-centered environment by including elements into the lecture series where students have to actively participate.

I realized that this more student-centered approach has been promoted for years and that it is at the core of current guidelines and suggestions being put forward to improve the education of future scientists (National Academies of Sciences, Engineering, and Medicine, 2018). So, one question to be asked is where do we currently stand in terms of teacher- vs. student-centered teaching? Or more generally, what teaching approaches are employed at universities in the natural sciences? What is the percent of the faculty that follows some of the suggestions proposed by numerous advisory committees? A current study from North America surveyed more than 2000 classes and over 500 faculty and observed their teaching by visiting and recording classroom behavior of teachers and students (Stains et al., 2018). Different observers were trained to complete the same spreadsheet while sitting in a classroom

[8] https://visible-learning.org/hattie-ranking-influences-effect-sizes-learning-achievement/

and recording what type of activity is being used in every 2-minute class interval. These data points were then collected and analyzed in a number of ways. For example, a clustering analysis resulted in the identification of seven different instructional profiles (Stains et al., 2018). These different teaching profiles were then further grouped into three instructional styles: "didactic", "interactive lecture" and "student-centered", with an overall occurrence of 55, 27 and 18 % respectively (Stains et al., 2018). The didactic style has more than 80% of classroom time devoted to traditional lecturing, interactive lectures are supplemented with some group activities and in student-centered lectures a larger portion of the time is spent on student-centered activities, like using worksheets (Stains et al., 2018). These results highlight that in 2018 in North America a large fraction of class time is still devoted to a very teacher-centric lecturing approach. Unfortunately, I am not aware of similar analyses in Swiss universities but from my own experience at the Universities of Basel, Bern and Fribourg I would hypothesize that the didactic instructional style is even much more prominent.

In summary, I would say that there have been only minimal changes in the teaching methods used over recent decades despite the fact that educational research strongly promotes the increased use of those approaches that involve students more directly during class time. It is somewhat surprising that scientist themselves actually do not follow a scientific approach for their own teaching, meaning that they do not follow the newest research results from that domain. Because at the same time, they certainly do follow the newest trends in their own scientific discipline and actually also expect this behavior of their students from the very beginning. There has to be a better way developed where every university instructor becomes aware of such new educational developments and I would support a notion where universities make a bigger effort in distributing such findings to their teaching faculty. There are information channels available, for example the University of Bern has a webpage with practical hints and ideas to optimize teaching[9] and is developing flyers for students and teachers with best practice suggestions, for example how to learn best[10]. But too often such information does not easily reach the end-user. I believe the newest educational

[9] www.didaktipps.ch
[10] lerntoolkit.unibe.ch

tools should be promoted more aggressively because supporting the learning of their students should be a main interest of universities.

1.2. primary literature in introductory courses

Good undergraduate education trains students to high subject literacy levels and one of the important elements of science processing skills is the assimilation of primary literature. Being able to process such literature is necessary for later job assignments and trains students in critical thinking and encourages state of the art data analysis. However, understanding and eventually writing such literature needs extensive training and, as with every task, it is advisable to start such training early on during a career. Previous research suggests that understanding primary literature is a continuing process that ideally goes on throughout the undergraduate curriculum (Krontiris-Litowitz, 2013). The study programs I know do incorporate some of this training, for example, by having students write term papers based on primary literature. Nevertheless, one cannot say that there is an emphasis placed on the integration of primary literature into the undergraduate classroom. I see different reasons why this is the case: primary literature is often difficult to read for the beginner and normally covers only a special topic. Undergraduate literature on the other hand should ideally be easy to understand and cover the basics of a subject. This is most often achieved by using textbooks that are used to guide the content of lecture series. Current biology textbooks are well organized and include all the basic information to provide a good overview of a subject. Moreover, they establish the common language that can be built upon. And while they are ultimately based on primary literature they are written in a synoptical and often accessible way. Despite this it is not uncommon to find introductory biology textbooks with up to 1500 pages which certainly goes beyond basic knowledge[11]. Maybe this is because it is difficult to define the basics of rapidly advancing fields but in my opinion such textbooks nowadays cover too much material for introductory courses lasting one (or sometimes two) semester. One is then tempted to cover a lot of this factual knowledge although I think most of it should not be

[11] at the University of Bern we use:
- Molecular Biology of the Cell, 6th ed., Garland Science, NY, USA, 1465 pages
- Campbell Biology, 11th ed., Pearson, London, UK, 1488 pages

presented in class. In principle, most of the textbook knowledge is easily accessible also on the internet so instructors nowadays could do without textbooks. One difficulty when not using textbooks is that it is not trivial to identify valid sources for a novice so the students have to be guided to good sources of information.

I am convinced that primary literature should be used more often in the classroom and that this would help students to reach a level of knowledge that prepares them well for either a future job or a continuing graduate career. It is primary literature that they have to read and understand once they finished their undergraduate studies. Primary literature indeed more closely reflects how scientists approach a problem and how the scientific process works. Research papers start by formulating a question and embedding the work in the current context. They then show the experiments and their interpretation and finish by providing future perspective. Such texts also allow the instructor to provide information that is up to date and they build upon the basic textbook knowledge whose content usually lags current research by several years. Research papers also give the opportunity to have unique classroom content and to have an emphasis on current approaches. However, such literature is often difficult because it is not written for a novice but for the expert in the field, and this makes it difficult for undergraduates to appreciate and understand the presented data. Nevertheless, this has to be practiced and one should start to read primary literature during their studies. One way to use primary literature is to have an instructor predigest it and present it in a form that everyone can easily follow. Another way could be to carefully select specific literature that is not full of jargon and well written so that students can understand it.

Taken together, and in order to achieve a better learning outcome, I want to have more student participation and incorporate more primary literature in my lecture series and here describe my first attempts towards reaching that goal.

2. Towards a more student oriented classroom environment

Ideally students leaving university should have a deep understanding of the subject of choice. On top of knowing the basic facts and theorems they should also be up-to-date with the knowledge in the field and this combination of knowledge and youthful openness can hopefully be the basis for new applications once students join the workforce after completing their degree. As discussed, this sought-after mindfulness has classically been trained for mostly by lecturing but achieving this literacy is probably easier reached with a newer set of didactic tools. Another way to think about this is to assess if the students starting a job are actually ready to go or if there is a lot they still have to learn on the job. It is an old saying that students are full of knowledge about theoretical, sometimes even outdated, details but that they have difficulties in performing practical work. Similar phenomena are also being observed in academic settings. For example, Carl Wieman, a Nobel prize winner in physics, who had observed many students going through his research lab, recognized a repeating pattern of student development (Wieman, 2007). Some of the very best undergraduates would be given a research question in his lab only to realize that it is completely unclear to them of how to initiate their research. The expectation is that they can apply what they learned during their studies to investigate the problems at hand by following a scientific approach. However, it turns out that in many cases the students have no idea of how to practically approach a problem and it takes a significant amount of time, years to be more specific, until they become independent scientists themselves and ultimately make their own discoveries. Is there something going wrong in undergraduate teaching? Could alternative teaching methods improve this situation? Research indeed suggests that lecturing is not the most suitable teaching method to develop independent and critical thinking. But with the introduction of additional and diverse teaching methods such skills could be specifically trained and better learning outcomes would likely be achievable.

Does this mean I think lectures are a thing of the past and should not be used anymore? Not at all, but maybe the structure of lectures can become more student-centric and create more social exchange among the participating people. More emphasis should be placed on the study of the scientific process itself as opposed to the current path of learning more and more factual details. Yet it should be clear that simply changing an instructional style will not necessarily result in a better outcome. It must be the combination of a useful style, a good preparation and a willingness in identifying and supporting the student's needs which all together can lead to a better result.

Analyzing learning in more detail reveals a large list of parameters that contribute to the learning outcome. These include everything from being organized and distributing well prepared handouts, to attending lectures and the type of infrastructure available to the instructor. Parameters can then be split into different groups: some will be mostly dependent on the teacher, others on the student and yet others are not easily influenced by the involved individuals; they are for example given by the environment and the circumstances the event is taking place in. Individual studies then describe and analyze such parameters in more detail and investigate their importance towards learning outcomes. An important question to be asked by the instructor is not only which parameters he or she can influence but also which ones ultimately have a big effect size and are most easily changed to reach more meaningful long term results. For example, a recent study investigated 105 variables in a large meta-analysis and ordered them in terms of relevance towards learning outcome specific for higher education (Schneider and Preckel, 2017). This study again highlights that social interactions are an important factor in achieving good results. In addition, it suggests that the teacher who presents information clearly, can relate lecture content to the student and uses demanding learning tasks will achieve higher learning outcomes (Schneider and Preckel, 2017). They also emphasize that investing in teacher training would likely make a big difference. Going through the list of variables can identify the ones that have a good effect without necessarily requiring a huge increase of pre-class workload for the teacher. Such variables include encouraging questions and discussions, being available and helpful, speaking clearly and distinctly or using open-ended questions (Schneider and Preckel, 2017). Fortunately, these points can essentially be changed without any additional time requirements by the instructor. However, it does require that the instructors are aware of the variables and that they make a specific effort to improve on such details, no matter how small they initially seem.

The question remains of why the current university faculty is surprisingly slow in adopting these findings and why classical lecturing remains so common in the undergraduate classroom. I believe most instructors are either simply not aware of the issues or don't take them serious enough. The good news is that many teaching methods exist that can result in creating a more student oriented teaching environment with increased student participation – we just have to use them!

2.1. Including everyone's voice in the classroom

As outlined biology students in Switzerland experience a highly didactic instructional style especially during the first four university semesters. A primary reason is class size, often classes can have 100's of students, and the consequence of such instruction leads to the expectation of the student body that all information is being presented to them and that they do not have to make an effort on their own to build an agreeable classroom environment. It is easier to blame the instructor than to blame oneself. I have heard several times that high school teaching is in essence similar but I personally cannot judge how currently is being taught at that level. In any case, students become increasingly passive and mainly attend lectures to consume information. Student questions are rare and questions by the instructor are only answered by few, often the same, students. In the end, most students are unwilling to actively participate during class time, it becomes a real challenge to change this behavior and ultimately many instructors shy away from the significant efforts necessary to elicit student responses and simply accept the situation. While it is understandable that there is reluctance in speaking up in front of a large class of people one doesn't know, it is unfortunate that the exchange deteriorates to such a low level. Ultimately the instructor is only one of the cogs and while he or she should lead by example the students have to play a constructive role for the lecturing machine to take off to new heights. Since more participation in the form of social interactions clearly seems to be advantageous for the ultimate learning outcome I wanted to try to include everyone's voice in the classroom. I chose to experiment with tools that generate more speaking by the students, including one where everyone was forced to actively participate at some point during the semester.

3. Case study: University of Fribourg

As part of my postdoc employment at the University of Fribourg I got the opportunity to teach in several different undergraduate courses. One course I was involved in, animal physiology (BL.0015), is a weekly 2-hour lecture series geared towards biology majors granting 3 ECTS[12]. It is a required course for Biology majors and generally taken in the 4th semester; at the same time, it can be taken as an optional course for example by students that do a minor in biology. No specific animal physiology textbook was required for this lecture series; however, a large part of the basic themes is covered in general biology textbooks that most people possess from other classes. Only the topics covered during classroom presentations were to be covered in the exam and all presentations were made available on Moodle. During the spring semester of 2016 I wanted to make a special effort to include elements that I identified were important for my personal teaching philosophy - increased student participation and inclusion of primary literature. This experience was also to be the basis for the current thesis.

3.1. Planning and overview

As biology undergraduate lecture series are inherently low in student participation I selected two different approaches to have the students more actively participate during the lectures. First I used an in-class live voting app to assist me in obtaining answers from the whole class by asking students exam like multiple choice questions that they answered using their own devices with online access. As a second element, I wanted to have the students participate in defining the actual course and exam material. For this I let the students chose a topic, had them pick a research article that they then had to summarize and present during class in front of their peers. Both these elements required active student participation and supported my goal to get different voices into the classroom. Together these adjustments helped changing the course format from a teacher monolog to a situation where there was more variability and they also generated additional breaks that participants could use to refocus.

[12] ECTS: European Credit Transfer and Accumulation System

This nearly semester long lecture series was held by three different instructors, and my part consisted of 5 out of the 12 lectures. Before the semester, we distributed the topics to be covered (Supplementary Table 1) and I volunteered to identify literature suitable for the student presentations and relevant for the lecture series to be presented during class time (Supplementary Table 2). I also suggested to use that material for the exam and I agreed to generate all the exam questions (Supplementary Table 3) as well as to do their corrections.

3.2. addition of elements to increase student participation

Many of my colleagues report the problem of the difficulty of having many students actively participate during such lecture settings. Moreover, having a lecture series where several different instructors participate does not make it easier as students have to adjust anew to each lecturer and get comfortable with the different environments.

The most common approach to solicit participation is to ask a question and let a student answer it. However, in the end it is not that easy to ask a question, ideally an open one, that is neither too easy nor too hard. Importantly one then also has to give enough time to actually let the students think about the question and to let them prepare an answer. It would also be a good idea to have several different people answer the same question. But way too often we fall into the same pattern in that it is always the same students that answer questions and everyone becomes comfortable with this situation. Of course, a simple possibility out of this would be to directly and randomly address different students after each question. However, this approach is dreaded by the students because one can feel very exposed or even humiliated especially if one didn't really understand the question or cannot answer it. Clearly other methods had to be employed. Moreover, for me as a beginning lecturer I didn't want to be too radical in enforcing participation but rather to start with small even subtle steps that can hopefully include more, ideally all, students in the lecture. For this series, I settled on using clicker questions and on organizing a student presentation series about current literature.

3.2.1. clicker questions

A simple way to have more students participate was the use of clicker questions. A “Clicker” is a type of audience response system that allows a teacher to ask a question that can then be simultaneously answered by all, or at least many, students and where the results can be displayed live in the classroom presentation. Clicker questions have been used for quite some time in the university classroom, initially mainly in the US, and research and reports about their usage became more widely available in the early 2000’s (reviewed in (Caldwell, 2007)). A broad variety of subjects, from philosophy to business and physics, and also education levels, from primary school up to graduate courses, have been using this tool and the general message is one that it often has positive effects towards student learning especially in larger classrooms and with the added benefit that they are also fun (Caldwell, 2007). One problem to a wider use were the initially high costs of the hardware. Handheld clickers had to be purchased for every class participant either by the school or the students themselves. Because nowadays most students come to class with a device capable to connect to the internet – be it a cell phone or a laptop – the previous hardware became obsolete. This lead to a revolution where a long list of app developers started to provide software solutions for education that are now available in the different appstores. I personally already used a few different apps in the classroom, including kahoot[13] and socrative[14]. Also, the learning platform supported by the University of Bern, Ilias, offers among the many add-ins a live voting solution; however, for the moment it has the disadvantage that it is not supported directly in PowerPoint. Here I will only further describe Poll-everywhere[15] one of the free solution that works very well in my hands. Although the free version is limited to 40 participants I have also used it in larger settings with the caveat that not all responses are recorded anymore. Their software integrates seamlessly into PowerPoint and students do not have to sign up with a personal account.

Using this software tool, it is easiest to prepare multiple-choice type questions that can then be used during the lecture. Such questions can serve several purposes: first they

[13] *https://kahoot.it/*
[14] *https://www.socrative.com/*
[15] *https://www.polleverywhere.com/*

allow a summative evaluation if students understood a particular concept that was just covered in the lecture. In addition, they generate a break where the students have to think and participate and where they have to leave the comfort zone of only consuming. Moreover, they allow for small discussion groups between students and they also lower the inhibition of the students to speak up. In my experience, it helps students to first discuss among themselves before they speak up in front of the whole class.

3.2.2. student presentations

The other tool we used to have students participate were student presentations. Oral presentations have many benefits and students will improve their literacy skills by preparing such presentations and practicing to communicate professional knowledge to their peers. Students also have to train in how to give effective presentations, a skill necessary for both professional or academic careers. Lecture series do rarely have such an element but to experience a variety of presenting styles and different speakers has not only a diverting effect but also forces the students to speak in front of the class and delve more into a specialized subject. Ultimately class size will decide if such presentations can be used during lecture series; here we had about 40 students that could be split in groups of 3-4 which ultimately lead to one (and sometimes 2) student presentations during each 2-hour lecture. In order to prepare the students for their presentation I provided them with a list of instructions, an example presentation and a Q&A session.

During the second week of the lecture series I went to class to explain in more details the expectations towards these presentations (Supplementary Presentation 1). I proposed to limit the presentation time to maximally 8 minutes and to have no more than 6 slides (Table 2). We also agreed to make the slides of the presentations in English. I provided them with a simple set of recommendations that they can follow while preparing their presentation (see below). At that time, I also stated that the content of the presentations will be material of the final exam and that this section will account for approximately 15% of the final grade.

To exemplify these explanations, I prepared such a presentation myself and this presentation was followed by some questions similar to the ones I intended to use during the final exam (Supplementary Presentation 2). Finally, we had a discussion hour a week later where I was present and answered all questions and discussed concerns regarding this new course element.

Table 2: Overview of student presentation design

	Slides	
	Purpose	Number
Introduction	Provide necessary background	2
Question	Selection of a particular question	1
Approach	Explanation of experimental design	1
Results	Outcome of the experiment	1
Conclusion and outlook	Meaning of results and follow-up question	1

3.3. inclusion of primary literature in the classroom

In principle, the student presentations could have been based on different types of material: for example, a summary from a part of a chapter in a textbook, or some popular media article about a given subject. As one of my goals was to introduce more primary literature into the lecture series I thought it would be ideal to use these presentations to cover such articles. Students have only little contact with primary research literature despite this being an important source of information during later stages of scientific or professional careers. This type of literature is generally written for an expert audience and it is often difficult and complicated to understand everything, unless one works in the respective field. The primary reason is that much of the necessary background cannot be covered as authors have to avoid content overlap and adhere to strict space limitations. I was convinced however, that with a careful selection of the articles it is possible for a novice to extract a main message, moreover, it was not necessary to understand every last experimental detail for this exercise.

To achieve a reasonable level and a uniform approach towards this exercise I used a set of recommendations that the students can follow while preparing their presentation. This also included tips of how to read and think about primary literature in general, a useful skill also for many other subjects. For example, we discussed an information leaflet suggesting to first skim, then re-read, interpret and finally summarize a given research paper[16]. I also proposed to first read the article at home and go through these points alone and then to discuss it within their respective group to hopefully clarify additional points in the group setting. I suggested that they use the introduction of the article as the basis for the presentation, maybe supplemented with some more general material from other sources including the internet. Then they should select one of the key experiments of the research paper that they want to present in more detail to the class. The goal was to explain one single experiment, to report the results obtained and to discuss the interpretations reached. I also told them not to get lost in the details and not to worry if there was some aspect that they didn't fully understand (Supplementary Presentation 1).

During the discussion hour the following week, I was ready to answer any additional questions the students had, either about content of the research papers or about the way to present. Not surprisingly, it turned out that the fact that the material was going to be covered in the final exam was the most worrisome aspect for the students. From their point of view, and based on their often limited previous experience with such literature, it was going to be very difficult to follow and understand all the presentations and to have such material covered in the exam. I could not do more than reassure them that I will formulate questions covering only the basics of their presentations. At that time, I also offered additional e-mail assistance if questions would arise at a later time.

While the student presentations were covering some cherry-picked experiments directly from recent primary literature they were not supposed to bring the lecture series itself up to date in terms of important scientific advances. One important selection criteria for the articles was simplicity and not necessarily scientific importance, several of the articles actually reported what could be paraphrased as "curious findings from the animal kingdom". For example, we had an article

[16] https://www.elsevier.com/connect/infographic-how-to-read-a-scientific-paper

investigating if one function of grooming within apes might be increased heat retention (Supplementary Table 2). Such research also allowed us to consider different types of research questions and, granted, was also entertaining. Other papers however, clearly are future textbook material, including an updated structure of myelinated neurons or the discovery of endothermic fish (Supplementary Table 2).

To cover additional current and important scientific discoveries, I also presented primary literature during my own lectures. Covering such new content serves several purposes: it keeps me up to speed with current research, and thereby stimulates also my own interests, and ensures that the lectures develop from year to year since novel findings are presented. It is quite exciting for me to be able to talk about something just discovered and to tell the students that this information is fresh from the press and that they will not encounter this information in the basic textbooks for several years. For example, during the lecture about reproduction I talked about a paper from yeast that experimentally verified the long standing hypothesis that sex speeds up adaptation at the molecular level (McDonald et al., 2016). This landmark paper was published just a couple of weeks before we covered it in the classroom. I believe also the students appreciate this up-to date information. Together the student presentations and the own research coverage provides an adequate level of timely information and ensures that we have unique classroom content not found anywhere else, be it in textbooks or internet resources.

3.4. Execution

Following a short description of how the individual elements were implemented in the actual lecture series.

3.4.1. Clicker questions

On average I probably prepared two clicker questions, in the form of single choice multiple choice questions, per two-hour lecture (Supplementary Figure 1). This type of questions was one of the types that we also used for the exam, although the in-class questions were usually a bit less concise than the actual exam question. I would show the questions in the PowerPoint slide and then give the students half a minute or so to decide for their preferred correct answer. After this initial time to think about the answer I sometimes encouraged short discussions between neighboring students for about another minute. At times the noise levels in the classroom during these discussions increased substantially but in my experience once the students are familiar with the procedure they can be settled down quickly again. They could enter their answer at any time point, changes were possible and actually I observed several times that the correct answer gained momentum over other choices over time. I then discussed with them the individual answers and explained why each option is either correct or false. During such explanation sessions, I got significantly more questions from the students for clarifications and sometimes we also discussed the question itself, as at times they were maybe not absolutely unambiguous. I found this actually to be helpful since it generated participation. These live questions created small breaks during the lecture and I tried to time them to allow such pauses in the middle of the respective lesson. Such breaks are also useful for other purposes, as they give students a chance to maybe finish a sentence in their notes, to refocus or simply to start again with the new topic that will follow. These questions were not part of the handouts and often I observed students taking pictures using their phones. However, I never used the same questions for the final exam. Certainly, they served as good elements to break up the sometimes rather serious lessons and also provide some entertainment.

3.4.2. Student presentations

After the presentation introducing the project during the second week students could start building their groups and sign up for their topic of choice in a first come first serve system. They then had to choose a primary research paper fitting the chosen topic either by selecting one themselves (with a confirmation by me) or by picking one from the provided list (Supplementary Table 2). Ultimately no group chose a new paper and all were selected from the provided list.

The first presentation was during semester week 4 so as to give those students also enough time to prepare their presentation. Nevertheless, there were also groups that had their presentation in the end of the semester, so these groups had much more preparation time. Paper presentations then had to be sent to the instructor 2 days before the lecture so that there was ample time to distribute it among the students through the Moodle platform where all presentations were uploaded. In agreement with the instructor's the presentations were then held either in the very beginning of the 2-hour class, after the break or sometimes even within a lesson at a point where it fit in. Personally, I chose according to the presentation so that it would fit nicely into the flow of the rest of the lecture. Students then held their presentation in German, French or English depending on their personal preference. Even though the goal was to keep the presentations under 8 minutes instructors did not cut presentations short. This approach worked reasonably well although in certain cases the students did take too much time. In that case instructors then had less time to cover their own material.

For several of the presentations the students followed up certain aspects about their specific topic in more detail, the presentations were mostly relatively easy to follow and generally of high quality. In few cases the presentations were basically read out from flashcards and in some instances clear nervousness by the presenters was observed.

Questions by the students about the student presentations were encouraged by the students themselves and also by me. However, only rarely a question came from the student audience. In few occasions, I asked a question. Sometimes I also followed up the presentation by an exam like question for the class as a whole so as to prepare them of what they can expect during the final exam. No formal feedback was provided to the students about their presentation except for some short discussions with the groups that were specifically seeking this type of feedback. During the class with the last presentation a questionnaire was handed out to get some student feedback about the project (Supplementary Table 5).

3.4.3. exam

For the final exam, I prepared a single true/false question about each paper presentation by the students. This way of testing was clearly communicated to the students already in the introduction to the exercise and I made sure that the students know that they do not have to read all the articles but that they can focus on the handout from the respective student groups distributed on Moodle. Moreover, several example questions were used during the semester to prepare the students for this type of questions. As I knew the students were quite insecure about having to know material presented by their peers from primary literature I wanted to make sure not to make it too difficult. Also for me it was the first time to embark on something like this and a minority of presentations were indeed not that clear but, according to the rules I made, still had to be tested on. In addition, I did not attend all the presentations myself and had to make some questions solely based on the presentation handouts. Also some of the students likely missed some of the presentations either due to illness or other reasons. In the end, I generated 14 questions, one about each student presentation, but had the students answer only 10 of them. I figured this would be a balanced approach to give them the chance to only have to answer questions about presentations they were attending and/or to pick the ones they understood best. Each correctly answered question resulted in 0.4 points, altogether these questions accounted for 4 points out of a total of 30 points, thereby representing 13% of the points in the final exam. The results were satisfying as most of the students did very well (Supplementary Table 4). The distribution of the results indicated that less than 10% of the students had 7 or less correct answers, which would correspond to a non-passing grade below 4.

3.5. Project evaluation

In the next sections I report some of my own conclusions that I gained from the implementation of the new elements in the lecture series. I then highlight some of the feedback I got from the students and present interpretations in how I thought the new elements were received. It would also be interesting to get some outside evaluation; this report could be the basis for such an analysis.

3.5.1. instructor view

A primary goal of the exercise was to increase student participation. Ideally one would use an independent classroom behavior analysis by some external person and this analysis should identify a measurable shift in student participation before and after introducing the new elements. I did not have such an analysis but I can perform a theoretical analysis according to the guidelines used to analyze STEM[17] teaching in

[17] STEM: science, technology, engineering and mathematics

the US (Stains et al., 2018). To keep it simple let us assume 10 minutes dedicated to the student presentation (14 presentations of 8 minutes each distributed into the 11 lectures) and two Poll-everywhere questions – with a combined duration of 4 min. Together these 14 minutes of student activities represent about 15 % of the total classroom time and this percentage alone would almost certainly lead to a change in cluster affiliation as defined by Stains et al., 2018. This assumes no other additional changes in classroom behavior even though these activities did create additional questions and discussions both from the students as well as from the instructor as described. Overall, I think the described lectures would fall well within the "interactive lecture" instructional style (Stains et al., 2018). Therefore, I personally consider the primary goal "to move the instructional style of a lecture series towards increased student participation" to be accomplished.

Of course, ultimately the goal would be that the overall learning outcome for the student is better than without student participation during the preceding lecture series. This is difficult to evaluate but would be the expected outcome according to previous research (Freeman et al., 2014; National Academies of Sciences, Engineering, and Medicine, 2018). Moreover, as the exercise helped training the students to read and report about primary literature I would expect additional long term positive effects for that skill. The exercise also trained the analysis of logical argumentation, forced students to interact and to critically evaluate each other's work while preparing the presentations, all of which are important elements for successful careers. Regarding factual knowledge, the students would not have learned something additional but I believe they did get a feeling of being more up-to-date and they reported a positive experience regarding primary literature.

3.5.1.1. clicker questions

Students love the novelty of any tech tool they are not familiar with and such aids are in line with the current trend towards digitalization. After asking the first Poll-everywhere question I asked the students if they had ever used it before. Actually, there were 2 or 3 that have used a similar tool in other occasions but it was new to a majority. To some extent it is surprising that still in 2016 so few people have had experience with such tools. Of course, the exciting novelty factor wears off quickly but

I consider it a useful exercise to get feedback from many students at the same time and to get some better idea if a concept has been understood. It is known that such live questions indeed force students to process some thoughts and that it helps to get some actual learning into the classroom. At the same time, there is probably an upper limit of how often it should be used and by how many instructors.

The questions I designed for this first round could certainly be improved upon. One disadvantage of the used software is that not too much text can be loaded into the individual answer possibilities which limits the construction of the questions a bit. It would be easiest to ask for simple memorized facts which however is not what I want to have the focus on. In a next round I would spend more time on generating more meaningful questions albeit it is exactly the fuzziness of the questions that sometimes increased active student participation.

3.5.1.2. Student presentations

The search and selection of primary literature suitable for the student presentations took a lot of time. Depending on the topic it was not easy to find literature that is of general interest, not too difficult to understand and up to date. Of course, this time commitment is necessary mostly during the first execution, in following years one could just add some new articles that are published during the past year and slowly exchange with some of the older ones[18]. One could also evaluate if articles that have been selected should be removed from the list.

The quality of the presentations was generally good although there was variation. This also came up in the student evaluations where it was mentioned that some presentations were not very clear (see below). Some selected presentations, for example ones with a clear structure and good design, could be stored in a course database as examples. Such a resource might help to improve the overall quality of the presentations as the students could profit from these examples. The quality of any given presentation also influences how much the rest of the class actually benefits

[18] Personal communication with the current Uni Fribourg animal physiology instructors revealed that paper presentations also took place in the 2017 and 2018 course iterations and that some additional articles were indeed added to the original list.

from the presentation. The other class participants can only profit something from it if a presentation is clearly structured and explained.

More feedback could have been provided to the students about their presentations. One reason for not promoting this was because the feedback would have had to be given by all three instructors. As I didn't want to force this upon the other instructors I also did not tell the students that they can expects formal feedback about their presentations. Some students would have preferred more of that although some also didn't want it.

The fact that there are major and minor biology students also affected the exercise. For certain minor students, the exercise might be more difficult; this point actually could be stressed specifically during the introduction, suggesting that minor students should team up with majors and not form groups by themselves.

3.5.1.3. exam

The questions about the presentations were answered very well, indeed probably too well. Maybe too many fail-save mechanisms were introduced in the end: not so hard questions and a requirement of only answering 10 out of 14 questions. The distribution showed that about half of the students (48%) had answered all of their 10 selected questions correctly (Supplementary Table 4). It would have been better to have more challenging questions in there and to have them answer more than only 10 out of the 14 questions. I realized however that these questions also had to be of a somewhat different design than the ones I actually would like to use during final exams. Ideally, I want to see if students understood a general concept or if they can apply something they learned in a new context. Here, I basically had to design questions solely based on the presentation handouts which essentially meant to create questions about the information stated on these slides. I could not ask about the general understanding of the study as most people did not actually read the article itself. On the other hand, this is the type of questions the students are more used to and they indeed like such questions. I also debated if I could try to generate some essay questions about the articles. The problem there would be that those groups that prepared the respective articles would have a clear advantage. Of course, the easiest option would be to not have questions about these presentations at all. If the decision would be to keep such exam questions I would increase the difficulty level of most questions so as to ideally come closer to a normal distribution of correct answers among the students[19].

The good thing about the used questions was that the obtained results might lead the students to appreciate that they actually understood the presentations and therefore that they understood some of the content of the research papers. This experience hopefully contributes to a more positive attitude towards primary research articles.

3.5.2. Student view

The 2016 animal physiology lecture series was not evaluated with the official university questionnaire by the students. Since the course was taught by a group of instructors, and the evaluation forms would not have assessed the new course elements, the general university form would not have been of great use to get specific feedback about the introduced student activities. Therefore, I generated an evaluation form myself to get student opinions about the presentation exercise (see below).

3.5.2.1. Clicker questions

The use of clicker questions has been very positively rated by students in several lecture evaluations from other courses I participated in. As this course was only the second one where I have used this tool, it was still new to most people and I believe that the students appreciated it[20]. The final exam is usually the most important issue for the students and therefore they take every opportunity to ask for help in preparing for it. Such questions give the students an idea of what to expect in the exam and they can evaluate their understanding of some of the material in real time. Moreover, it brings activity into the classroom which is not only important to improve learning outcomes but is an important element in actually bringing students into the classroom. Research suggests that such active participation is one of the major elements that makes lectures “unmissable” (Revell and Wainwright, 2009).

[19] during the 2017 lecture series similar exam questions about student presentations were still used; however, in 2018 exam questions about the student presentations were aborted.
[20] The presentation evaluation form had an open comment box where one student mentioned that the Poll-everywhere questions “are very useful to understand a topic”.

3.5.2.2. Student presentations

To gain some specific insight about how this exercise was perceived by the students I generated a questionnaire in order to solicit some feedback and opinions about it (Supplementary Table 5). With this questionnaire, I wanted to evaluate the student's general view about the exercise, the experience of working together as a group, to see if they gained something by listening to each other's presentations and the necessary time investment. These results were going to be an important part of the exercise evaluation and were going to help determine how the exercise was going to be carried out in coming years. The overall results were certainly encouraging. Following are short discussions of five points, I judge to be the most important ones, from the evaluation forms that I received (Supplementary Table 6).

<u>Point 1:</u> 78 % students suggested to repeat the student presentations in the coming year, while 10 % recommended to abort student presentations.

This is an overwhelmingly positive response to the exercise as a whole – clearly the students appreciated it and were in favor of repeating it. I interpret this result as an indication that the students thought the extra time they had to invest was useful and that they learned something by participating.

For most of the questions, including Points 2-5, I used the following 5-point scale:

(1) fully agree
(2) agree
(3) neither agree nor disagree
(4) partially disagree
(5) fully disagree

<u>Point 2:</u> When asking if the students found it useful to read and explain a research paper the students answered with an average of 1.4; listening to the other presentations the usefulness was judged with an average of 2.2.

This result indicates that the students perceived the presentations much more useful if they actually prepared them themselves. It may suggest that listening to the other's presentation is not that different than listening to the instructor and in that sense generates no added value to the student who is listening. It also reinforces the concept that being actively involved, here by reading, discussing and preparing the presentation, creates a more positive memory which hopefully translates into a better learning outcome.

Point 3: When asked if they enjoyed to do the exercise as a group the answer was 2.5. At the same time, an answer to another question indicated that the group work helped to better understand the article, as this was scored with a 2.

This first answer was the only one to be right in the middle of the scale and indicates that working as a group was not that agreeable for everyone. My intention was to create a situation where students interact and maybe help each other understand some of the details of the research article, which was partially confirmed by the second question. From my experience biology students rarely work together and this might be one of the reasons why it was difficult for them and why the benefits are maybe not easily recognized. However, I think working and deciding as a group is an important aspect of later working environments and should be trained more often.

Point 4: On average students used three and a half hours for their preparation of the presentation.

Here I was somewhat surprised as I would have actually expected a somewhat bigger time requirement, although there was a spread of answers ranging from 1 up to 10 hours. I know that just reading the article carefully already takes more than an hour. Then there should have been discussions and finally the presentation had to be prepared. It is certainly possible that some groups actually split the work and each member did only a part which would be one way to cut the time requirements. Another possibility is that the question I asked was not clear enough as I was asking for "the time spent to do the presentation" and not "the time spent overall" which is actually what I wanted to know.

Point 5: I also inquired if the students would appreciate more specific feedback.

The class was split: 54 % of the students would have liked more feedback while for 46 % the setup was satisfactory the way it was.

Overall the evaluations paint a picture that shows that the students left with a positive attitude towards the exercise. This is encouraging especially in the light that it did involve extra work for the students. It was also apparent that some individuals were nervous and giving the presentations must have been stressful for some students. However, everyone participated and ultimately a big majority of students rated it in a positive way. I would therefore strongly encourage similar exercises in the future and I will try to incorporate student presentations also in other settings if possible.

4. Future directions

When starting the didactics course I imagined this exercise to continue over the course of up to three years. I wanted to take the personal experiences and the results of the evaluations into account for the next round of the course during the spring semester of 2017. Ultimately this was not the case because I got the opportunity to start a lecturer position at the University of Bern and switched jobs in fall 2016. Due to this I could not refine, and hopefully further improve, student participation elements and their implementation in this course. Nevertheless, I was happy to find out that the student presentations about current literature articles continued in this course in the 2017 and 2018 iterations. In the near future, I would like to reach student participations of about a third of the class time during my lectures. Additional dedicated group activities will be necessary to reach this goal. Currently I do not teach a class with a similar number of students at the University of Bern. I do, however, continue to use clicker questions and also had student presentations in other courses and settings.

4.1. Clicker questions

I have used clicker questions already in previous events and in my first attempts of using live voting questions I tried to evaluate if the students could remember a just discussed topic. I looked at the results in a purely summative way and did initially not realize the full potential this method actually provides as an instructional tool. Subsequently, I shifted more towards conceptual questions by using novel examples that can better assess if a new concept was fully appreciated. Even later I became aware of the concept of peer instruction that can be implemented with the help of such questions. Eric Mazur was a main driver of developing and promoting this learning method and he convincingly showed that it helps student's conceptual reasoning and quantitative problem solving (Crouch and Mazur, 2001). The idea is that one uses more challenging questions and first lets every student answer them independently. In a second step students should identify a neighbor that gave a different answer to the question and then try to convince her/him of their own answer. Logic predicts that the person with the correct answer has a better argumentation since s/he indeed understands the concept and is therefore more likely to be able to convince a neighbor. After a couple of minutes once again the same question will be shown and students re-answer it. Interestingly, often more people will get the right answer in the second round. The whole procedure is followed by additional explanations by the instructor. Following research verified that it is the discussion and argumentation about the concept between the students, and not simply the peer influence of knowledgeable students to their neighbors, that increases the number of correct answers (Smith et al., 2009).

I have not yet personally tried to use the clicker questions in this format. But clearly this looks to be a strong improvement over simple summative evaluation of such questions. It is a plausible outcome that students can explain each other a concept better in their own language than an instructor can who maybe forgot where exactly the difficulties are for the novice learner. I will certainly try to invest more time in the generation of more useful clicker questions and hopefully try out this concept in more detail in the near future.

4.2. student presentations

One problem of the student presentations is the difficulty in defining and setting standards for these presentations. The better organized the presentations are the more students can actually appreciate each other's work and take something from it. One option might be to have an instructor pre-screen the presentations, which would need additional time. At the same time, there should be a learning effect and the more often such exercises are performed the better the students might become. This however has not been observed within the semester, meaning that the last presentations were not significantly better than the first ones. Also, the experience of a somewhat confused audience might give important inputs to the presenting as well as to the listening students. In another course, I am currently trying to implement a way to have students evaluate and possibly grade the presentations of their peers albeit in a smaller class setting. In the future, I would also like to further encourage textbook reading of some basic knowledge at home, ideally before the class, and present such information only as an overview in order to have enough time for more exciting content.

Another positive aspect of the student presentations was that they could actually steer the content of the lecture series, although only to a small extent. I liked this because it shows the students that there is flexibility in the selection of the material and that examples for certain concepts can be chosen freely.

Having such student presentations limits the class size to an upper limit. I believe one to two presentation per lecture should not be exceeded. This means with a group size of 3 we are talking about class sizes of maximally 50 students. Much more would become difficult with this format as it would take too much of the time.

4.3. exam

Grades and final exams are among the strongest motivators for students. For this reason, I made the student presentations part of the exam because under such circumstances the exercise becomes immediately more official and important. The implementation however was not easy as it generated a conflict with the types of questions I would like to use in exams. Therefore, I would advise to discontinue exam question about the student presentations.

Ideally the gains in professional development through such an exercise would be enough for the students to prepare their presentations seriously. But since not every student has high intrinsic motivation for this class, and its additional work requirements, this might be difficult. Presenting together with a group should be advantageous here as the more motivated students would make sure to have a good presentation. Maybe additional ideas are needed in the future to explain the benefits to the students.

4.4. additional elements

Obviously, student participation can also be increased with countless other teaching elements. Depending on class size different types of activities can be more easily incorporated. Currently I have responsibility for 3 classes at the University of Bern: one with 14 students, one with around 80 students and one with >200 students. I use clicker questions in the two big classes and student presentations in the small class. In addition, last semester I have used a different activating method every week in the small class; this class give me a good opportunity to try out new approaches in a real setting but with a class that is more easily manageable (also see validation report for Didactic Module A3). I want to continually evaluate which activities could also be easily implemented in the bigger settings. For example, in the 80 students class I have experimented with group games and handouts and in the big class I have used worksheets. As I get more and more familiar with the overall content of the classes it also becomes easier to try out new approaches.

5. Discussion

In the end, I want to shortly discuss the way novel pedagogical concepts spread within the university environment. I reported that the natural sciences are slow in adapting such new developments and teaching practices have changed little during the last two decades. The underlying premise is that the new methods are better suited to significantly improve knowledge retention and conceptual understanding among the current student population. And here lies the problem in that there is not a universally valid approach that would always generate a better educational outcome – study programs, learning objectives and instructors themselves vary significantly and ultimately every person learns best in a different way. Nevertheless, it seems clear that a more student oriented and problem - based learning environment would result in overall better learning outcomes (Freeman et al., 2014). The question then becomes of what could be done to speed up the process of spreading the knowledge of this improved way of teaching.

Changing a current culture is generally regarded as a difficult process unless the advantages are very obvious. Cultural changes can depend on many factors including invention, leadership changes or diffusion. It is easiest to appreciate how a new invention can drive a cultural change, for example the invention of cell phones has essentially changed the world in a mere 30 years. With teaching, we don't look at a new invention but at the discovery that certain ways of teaching can have positive influences on learning outcomes, although they sometimes might be subtle. But many variables will affect the observed outcome and often it is not the methodological change alone that explains an observed change. Due to these difficulties, such new insights and practices might only slowly diffuse across disciplines and countries which is essentially what we observe.

Cultural change is its own research discipline and cultural evolution tries to understand how evolutionary concepts influence cultural change (Henrich and McElreath, 2003). In essence the idea is that a culture, for example defined as a human acquisition like a custom or a language, is passed on from person to person and through generations in a process that can be described with ideas stemming from Darwinian evolution.

Interestingly such a model has recently been applied to suggest a way to more quickly implement a cultural change in university teaching (Grunspan et al., 2018). Several factors have been incorporated in the modelling, including the global nature of teaching, the generational time of university professors and academic career trajectories (Grunspan et al., 2018). The suggestion the authors propose to speed up the cultural change in teaching is one where especially in high profile universities pedagogy courses should be incorporated into their PhD programs (Grunspan et al., 2018). Education programs in high profile universities are most beneficial because those places produce the highest number of alumni that end up with professor positions all over the world. By this scheme, the next generation of teachers would lead by recollection and distribute their own experiences, now including improved pedagogical skills, in a similar way as it is done now. I find this a reasonable proposition and one that would work well in parallel to the current bottom up approach. Now governing university bodies would have to embrace this and enforce an improved teaching education through a political change.

6. Personal reflections

Personally, it has been a great journey for me. I began the didactics program at the University of Fribourg after starting to give lectures for undergraduate students there. Quickly I became more interested in learning about different teaching approaches mainly because I simply wasn't convinced that the lecturing I did represented an ideal method. Lecturing itself was not questioned by the responsible persons of the study program, the department did not provide formal support and it didn't seem that anyone around me was really thinking about ways to develop and use current teaching practices. Essentially it felt like being part of an ocean ship maneuvering under auto pilot where the direction is given – you have to lecture – but where the behavior of each individual sailor is irrelevant – you can do in the classroom whatever you want. Actually, I was slightly surprised in that the university doesn't provide more direct input, nor do they really monitor their staff's teaching, because the education of their students should be one of their priorities. The different didactics courses gave me ample opportunities for exchange of ideas, theoretical background and the possibility to develop a vision of what good teaching would look like for me. I am convinced that a large part of the faculty could profit immensely from learning more about different teaching methods and the research behind it. And the more I learn about it the more I believe it would result in actual changes.

Of course, I also quickly realized that there is not a single best approach to good teaching – there is no one-size-fits-all solution. Many variables are at stake and it is often difficult to pinpoint the individual elements that have significant positive effects. In that sense, it is not the type of science I am used to from my day to day work where we try to design and interpret experiments with a single changing variable. I see the lack of clear and easy to follow instructions as the main issue in changing the culture of teaching in university science departments. But as every class is different and every person in there has a different mind-set it is practically impossible to develop such guidelines. Certainly the other big issue is that most university instructors have essentially nothing to gain if they spend more time in preparing a good course geared towards better student understanding. But most of my peers, and still including myself, have little idea of all the research and data that is out there showing cases where novel teaching approaches could significantly increase the learning outcome in a student population. Now being employed as a lecturer gives me the freedom to use some of my time to investigate such questions and in that sense, it would be advisable to hire more faculty dedicated to teaching.

I try my part in using and promoting some of the didactic concepts I learn and learned about and in spreading them among my colleagues. For example, during a recent scientific symposium I chose to give a talk entitled "Is lecturing still a valid teaching method?" instead of talking about my research. I believe the audience was interested and also receptive for the presented ideas. I want to bring alternative teaching methods into the minds of science instructors and help to convince them that they could probably improve learning outcomes of their students by using additional tools. I can support the cultural change by initiating conversations and exchanging ideas with my colleagues. Many interesting conversations have developed from these encounters. A main message is that we have to realize that we actually do not have to completely change our teaching style but we should simply present the material slightly different and in ways that activate the students to think and discuss the material.

Such changes, even if small, are probably best introduced step by step and then adjusted and refined over the course of a lecture series and from semester to semester. Moreover, one should not be discouraged if something doesn't immediately work as planned. It takes perseverance and a will to learn in order to stay at the forefront of new developments in education just as in every other research discipline. That said I'm looking forward to many more iterations of my courses and I believe I can continuously improve my teaching approaches and hopefully offer classes that are useful, enjoyable and with a lasting impact to everyone involved.

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8. Overview Supplementary Material

Supplementary Table 1: overview of topics and instructors animal physiology FS2016

Date		Topic	Lecturer
26.2.	W1	Intro / Digestion	x
4.3.	W2	Digestion	x
		Intro & Example Paper Presentation	M. Brauchle
11.3.	W3	Discussion Paper Presentation	M. Brauchle
		(no lecture)	
18.3.	W4	Neuron Structure and Function	x
8.4.	W5	Sensory Systems 1	M. Brauchle
15.4.	W6	Sensory Systems 2	M. Brauchle
22.4.	W7	Ion and Water Balance	x
29.4.	W8	Reproduction	M. Brauchle
13.5.	W9	Hormonal Systems	x
20.5.	W10	Thermal Physiologie	M. Brauchle
27.5.	W11	Respiratory Systems	x
3.6.	W12	Circulatory Systems	M. Brauchle

Supplementary Table 2: list of papers for the in-class student presentations

W2
1. An In-Depth Analysis of a Piece of Shit: Distribution of Schistosoma mansoni and Hookworm Eggs in Human Stool
   Krauth et al., (2012) Plos Negl Trop Dis DOI: 10.1371/journal.pntd.0001969

W4
1. Glia-derived neurons are required for sex-specific learning in C. elegans
   Sammut et al., (2015) Nature 526, 385-390
2. Distinct Profiles of Myelin Distribution Along Single Axons of Pyramidal Neurons in the Neocortex
   Tomassy et al., (2014) Science 344, 319-324

W5
1. A Different Form of Color Vision in Mantis Shrimp
   Thoen et al., (2014) Science 343, 411-413
2. The Role of Age-Specific Learning and Experience for Turtles Navigating a Changing Landscape
   Roth and Krochmal (2015) Curr Biol 25, 333-337
3. Evening use of light-emitting eReaders negatively affects sleep, circadian timing, and next- morning alertness
   Chang et al., (2015) PNAS 112, 1232-1237

W6
1. Electric Eels Concentrate Their Electric Field to Induce Involuntary Fatigue in Struggling Prey
   Catania (2015) Curr Bio 25, 2889-2898
2. Molecular basis of infrared detection by snakes
   Gracheva et al., (2010) Nature 464, 1006-1011
3. Bears Show a Physiological but Limited Behavioral Response to Unmanned Aerial Vehicles.
   Ditmer et al., (2015) Curr Biol 25, 2278-2283

W7
1. The water channel aquaporin-1a1 facilitates movement of CO2 and ammonia in zebrafish (Danio rerio) larvae
   Talbot et al., (2015) JEB 218, 3931-3940
2. No Evidence of Dehydration with Moderate Daily Coffee Intake: A Counterbalanced Cross-Over Study in a Free-Living Population
   Killer et al., (2014) PlosOne DOI: 10.1371/journal.pone.0084154
3. Novel Mitochondria-Targeted Heat-Soluble Proteins Identified in the Anhydrobiotic Tardigrade Improve Osmotic Tolerance of Human Cells
   Tanaka et al., (2015) PlosOne DOI: 10.1371/journal.pone.0118272

W8
1. Pest control and resistance management through release of insects carrying a male-selecting transgene
   Harvey-Samuel et al., (2015) BMC Bio 13:49
2. Ecological Knowledge, Leadership, and the Evolution of Menopause in Killer Whales
   Brent et al., (2015) Curr Biol 25, 746-50

W9
1. Exceptionally low daily energy expenditure in the bamboo-eating giant panda
   Nie et al., (2015) Science 349, 171-174
2. Oxytocin-dependent consolation behavior in rodents
   Burkett et al., (2016) Science 351, 375-378
3. Sexual Deprivation Increases Ethanol Intake in Drosophila

Shohat-Ophir et al., (2012) Science 335, 1351-1355

W10
1. Thermal Consequences of Increased Pelt Loft Infer an Additional Utilitarian Function for Grooming
   McFarland et al., (2015) Am J of Primatology
2. Whole-body endothermy in a mesopelagic fish, the opah, Lampris guttatus
   Wegner et al., (2015) Science 348, 786-789
3. Seasonal reproductive endothermy in tegu lizards
   Tattersall et al., (2016) Sci Adv 2:e1500951
4. Summer declines in activity and body temperature offer polar bears limited energy saving
   Whiteman et al., (2015) Science 349, 295-298

W11
1. Eggshell Porosity Provides Insight on Evolution of Nesting in Dinosaurs
   Tanaka et al., (2015) PlosOne DOI: 10.1371/journal.pone.0142829
2. Ventilation rates and activity levels of juvenile jumbo squid under metabolic suppression in the oxygen minimum zone
   Trübenbach et al., (2015) JEB 216, 359-368
3. Termite mounds harness diurnal temperature oscillations for ventilation
   King et al., (2015) PNAS 112:11589-11593
4. Tracheal compression in pupae of the beetle Zophobas morio
   Pendar et al., (2015) Biol Letters 11: 20150259. DOI: 10.1098/rsbl.2015.0259

W12
1. Topsy-turvy: turning the counter-current heat exchange of leatherback turtles upside down
   Davenport et al., (2015) Biol Lett 11:20150592. DOI: 10.1098/rsbl.2015.0592
2. Exercise at depth alters bradycardia and incidence of cardiac anomalies in deep-diving marine mammals
   Williams et al., (2015) NCommun 6:6055 DOI:10.1038/ncomm7055
3. Structural and functional features of central nervous system lymphatic vessels
   Louveau et al., (2015) Nature 523, 337-341

Supplementary Table 3: exam questions covering the paper presentations

The following questions regard the student paper presentations
Each statement is either correct (+) or wrong (-), please indicate accordingly
Important: please only answer 10 of the 14 questions (leave the rest blank or cross some out)
(0.4 points per question. Maximum of 4 points)

☐

1. The paper "Distinct profiles of myelin distribution along single axons of pyramidal neurons in the neocortex":
… uses reconstructions by electron microscopy to investigate the myelin content along neurons.
… nutzt Rekonstruktionen mittels Elektronenmikroskopie um den Myelingehalt entlang Neuronen zu untersuchen.
…utilise des reconstructions part microscopie électronique pour étudier le contenu de la myéline le long de neurones.

☐

2. The paper "The role of age-specific learning and experience for turtles navigating a changing landscape":
… claims that only adult turtles can find a new water point.
… behauptet, dass nur erwachsene Schildkröten eine neue Wasserstelle finden.
… affirme que seules les tortues adultes peuvent trouver un nouveau point d'eau.

☐

3. The paper "Evening use of light-emitting eReaders negatively affects sleep, circadian timing and next morning alertness":
… measures Melatonin levels as an important readout for their conclusions.
… misst den Melatoninspiegel als eine wichtige Anzeige für ihre Schlussfolgerungen.
… mesure les niveaux de mélatonine comme une lecture importante pour leurs conclusions.

☐

4. The paper "Electric eels concentrate their electric field to induce involuntary fatigue in struggling prey":
… shows that these eels hunt in groups.
… zeigt, dass diese Aale in Gruppen jagen.
… montre que ces anguilles chassent en groupes.

☐

5. The paper "Bears show a physiological but limited behavioral response to unmanned aerial vehicles":
… measures the heart rate as a proxy for physiological response.
… misst die Herzfrequenz als Proxy für die physiologische Reaktion.
… mesure la fréquence cardiaque comme un proxy pour la réponse physiologique.

☐

6. The paper "No evidence of dehydration with moderate daily coffee intake: a counterbalanced cross-over study in a free-living population":
… claims that 4 spoons of sugar in the coffee does not affect the dehydration level.
… behauptet, dass 4 Löffel Zucker im Kaffee keinen Einfluss hat auf die Höhe der Dehydratisierung.
… affirme que 4 cuillères de sucre dans le café ne modifient pas le niveau de déshydratation.

☐

7. The paper "Pest control and resistance management through release of insects carrying a male-selecting transgene":
… studies if males are more likely to become a pest because they are more resistant to toxins.
… untersucht ob Männchen eher eine Plage werden, weil sie resistenter gegen Toxine sind.
… étudie si les mâles sont plus susceptibles de devenir un ravageur parce qu'ils sont plus résistants aux toxines.

8. The paper “Ecological knowledge, leadership, and the evolution of menopause in killer whales”:

… claims that menopause is a consequence of showing leadership and ecological knowledge.

… behauptet, dass die Menopause eine Folge von Führung und ökologischem Wissen ist.

… affirme que la ménopause est une conséquence de faire preuve de leadership et de connaissances écologiques.

9. The paper “Exceptionally low daily energy expenditure in the bamboo-eating giant panda”:

… suggests that giant pandas have such low energy expenditure due to small organs, deep pelage and low activity.

… schlägt vor, dass Riesenpandas so niedrigen Energieverbrauch haben aufgrund kleiner Organe, dickem Fell und niedriger Aktivität.

… suggère que les pandas géants ont une si faible dépense d'énergie en raison de petits organes, d’un pelage épais et d’une activité faible.

10. The paper “Oxytocin-dependent consolation behavior in rodents”:

… finds that all tested rodents (prairie voles and meadow moles (M. ochrogaster and M. pennsylvanicus)) show consolation behavior.

… stellt fest, dass alle getesteten Nagetiere (M. ochrogaster und M. pennsylvanicus) Trostverhalten zeigen.

… constate que tous les rongeurs testés (M. ochrogaster et M. pennsylvanicus) présentent un comportement de consolation.

11. The paper “Summer declines in activity and body temperature offer polar bears limited energy savings”:

… shows that polar bears have no easy means to save more energy during summer.

… zeigt, dass die Eisbären keine einfachen Mittel haben mehr Energie während des Sommers zu sparen.

… montre que les ours polaires ont aucun moyens faciles d'économiser plus d'énergie pendant l'été.

12. The paper “Thermal consequences of increased pelt loft infer an additional utilitarian function for grooming”:

… used special devices implanted in live monkeys that measured the physical properties of pelt before and after grooming.

… benutzte spezielle Geräte implantiert im lebenden Affen, welche die physikalischen Eigenschaften von Fell vor und nach der Fellpflege gemessen haben.

… a utilisé des dispositifs spéciaux implantés chez des singes vivants qui ont mesurés les propriétés physiques de la fourrure avant et après le toilettage.

13. The paper “Eggshell porosity provides insight on evolution of nesting in dinosaurs”:

… showed that egg porosity is highly correlated with nesting type and can be used to predict the nests of extinct species.

… zeigte, dass die Eiporosität und der Nesttyp stark korrelieren und somit benutzt werden kann um Nestarten von ausgestorbenen Arten vorherzusagen.

… a montré que la porosité des oeufs est fortement corrélée avec le type de nidification et peut être utilisée pour prédire le nid d’espèces disparues.

14. The paper “Turning the counter-current heat exchange of leatherback turtles upside down”:

… shows that leatherback turtles always swim upside down.

… zeigt, dass Lederschildkröten immer auf dem Kopf schwimmen.

… montre que les tortues luths nagent toujours à l'envers.

Supplementary Table 4: test results

Number of students participating in the exam: 44

Distribution of results:

Correctly answered questions:	10 out of 10	21
	9 out of 10	11
	8 out of 10	9
	7 out of 10	1
	6 out of 10	1
	5 out of 10	1
	less than 5 out of 10	0

Supplementary Table 5: student questionnaire

The following questions concern only the “Student Paper presentations” during the FS16 Animal Physiology lectures.

Please indicate your personal opinion according to the following 5 - point scale:

(1) Fully agree
(2) Partially agree
(3) Neither agree nor disagree
(4) Partially disagree
(5) Fully disagree

---

1. ____ The task was well explained & the expectations for the in-class presentations were clear
2. ___ The topics of the papers were relevant for the course
3. ___ Most of the papers/presentations were too complicated for this exercise
4. ___ I believe I understood the main message of (most of) the presented papers
5. ___ I'm convinced that the others understood the main message of my own presentation
6. ___ It was useful/interesting for me to read and explain a current research paper
7. ___ It was useful/interesting for me to hear 13 other current research papers by the others
8. ___ I enjoyed discussing and preparing the paper in the group
9. ___ Working in a group helped me understand the paper better as if I would have done it alone
10. ___ The presentations gave me a better idea of what current researchers are doing
11. ___Specific feedback for the presentation would be useful
12. ___ The presentations took the right amount of time. 12A. If not: longer or shorter?____
13. To prepare my own presentation I used approximately ____ hours of preparation
14. I liked most:
____

____

15. I didn't like:
____

____

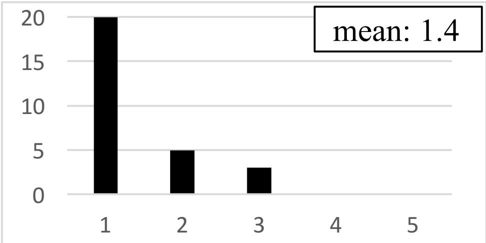
16. I would have wished for more support by the lecturer's	o Yes	o No
17. I actually seeked support	o Yes	o No
18. I would appreciate group feedback after the presentation	o Yes	o No
19. I would recommend doing this again in next year's course	o Yes	o No

---

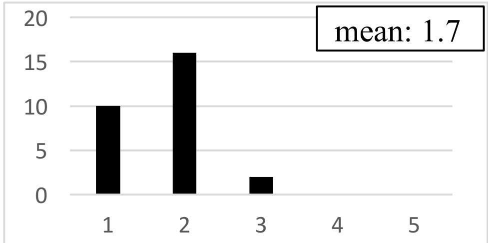
20. Additional comments (also about M. Brauchle's lectures in general):

Supplementary Table 6: results of student questionnaire (n=28)

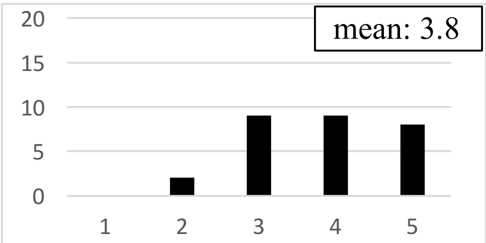
1. The task was well explained & the expectations for the in-class presentations were clear:



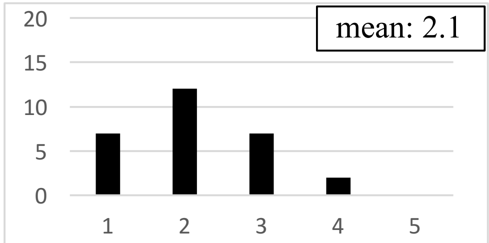
2. The topics of the papers were relevant for the course:



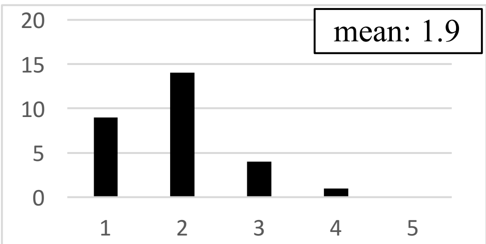
3. Most of the papers/presentations were too complicated for this exercise:



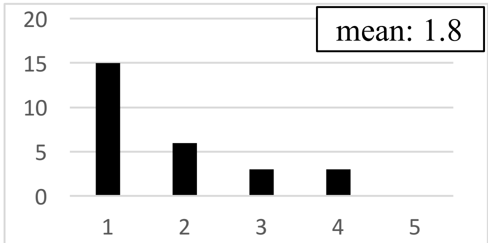
4. I believe I understood the main message of (most of) the presented papers:



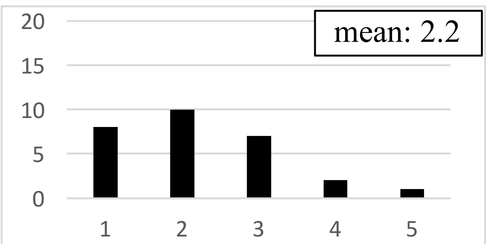
5. I'm convinced that the others understood the main message of my own presentation:



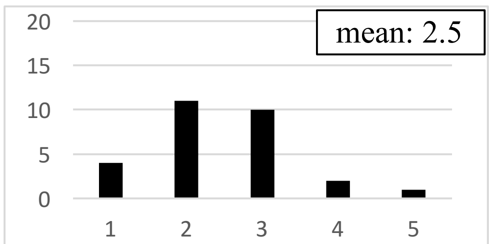
6. It was useful/interesting for me to read and explain a current research paper:



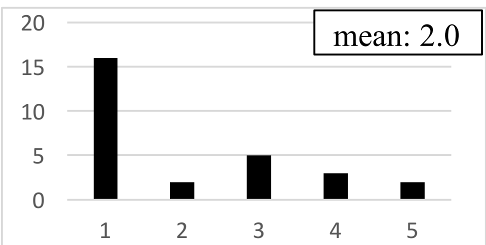
7. It was useful/interesting for me to hear 13 other current research papers by the others:



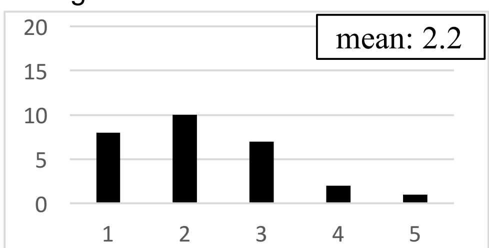
8. I enjoyed discussing and preparing the paper in the group:



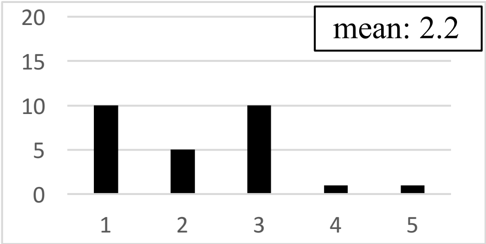
9. Working as a group helped me understand the paper better as if I would have done it alone:



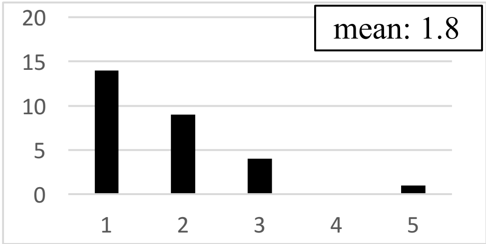
10. The presentations gave me a better idea of what current researchers are doing



11. Specific feedback for the presentation would be useful:



12. The presentations took the right amount of time:



12A: If not: longer or shorter?
- longer
- 10 minutes

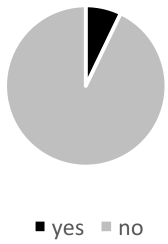
13. To prepare my own presentation I used approximately __ hours of preparation:
mean: 3.4 hours (range: 1-10 hours)

14. I liked most:
- l'originalité des papiers présentés
- see current work
- découvrir de nouvelles choses
- topics of the papers were good selected
- understanding the paper after numerous readings
- read a current research paper
- to see how a theory is applied in an experimental method
- reading and understanding the paper
- es ist gut, dass man einmal die Möglichkeit hat etwas zu präsentieren; es ist gut einmal wissenschaftliche papers lesen zu müssen und sich damit auseinanderzusetzen.
- es ist eine gute Übung braucht aber zusätzlich Zeit
- to discover new subjects
- short paper, large choice of subjects, links to the course; nice we could do it in french/german
- working in groups, discussing
- read a research paper
- learn something specific
- reading a scientific paper
- les articles permettent de voir la théorie sous an angle appliqué et plus concret

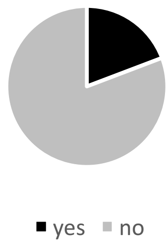
15. I didn't like:
- tous le monde devrait faire en anglais
- pas facile de bien comprendre un article en anglais
- some papers were maybe too complicated
- maybe some of them were too complicated
- doing the presentation
- dass die Präsentationen Prüfungsstoff sind. Nicht alle Präsentationen waren klar verständlich, bei einigen war nicht klar was genau im Paper untersucht wurde und was die conclusion war.
- die Paperpräsentationen als Prüfungsstoff finde ich schwierig, weil zT der Hintergrund fehlt und keine Zeit bleibt um alle Paper zu lesen. Einige waren sehr unverständlich
- to talk in front of a group
- the topic, maybe to chose it freely would be better
- could you make sure that students use a simple language, no matter in which language they talk. It was very difficult to understand french speaking people who talk english (I'm a

german speaker)
- sometimes not well presented; no feedback
- not enough time to report everything in 8 minutes

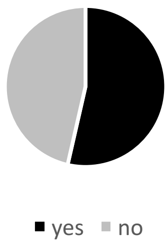
16. I would have wished for more support by the lecturer's



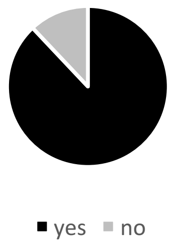
17. I actually seeked support



18. I would appreciate group feedback after the presentation

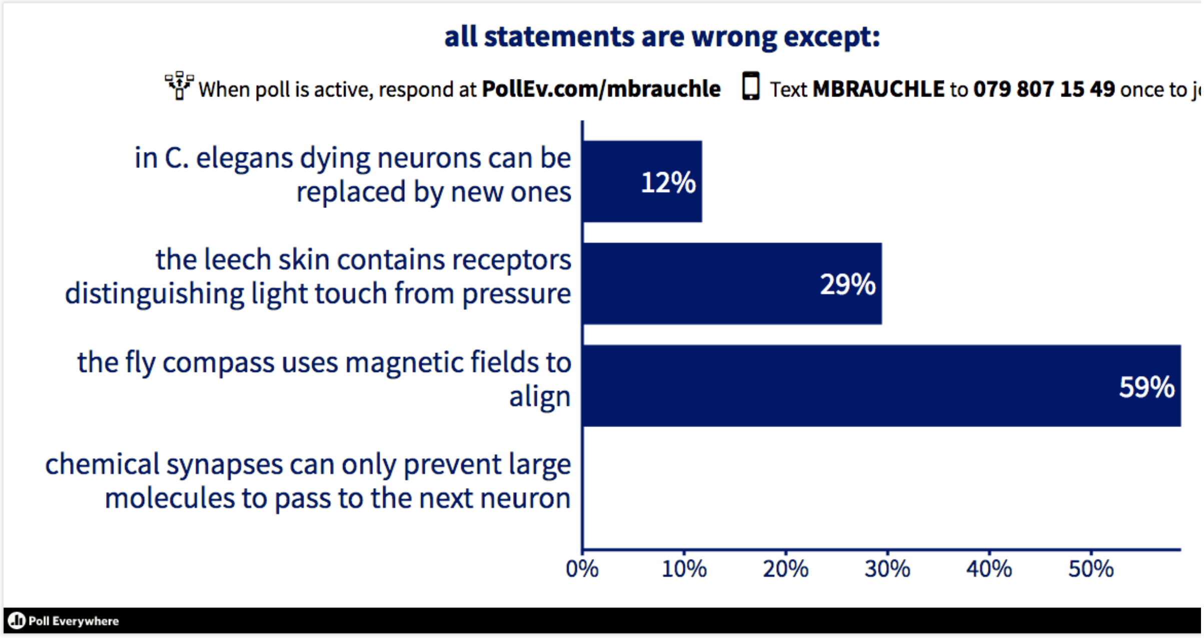


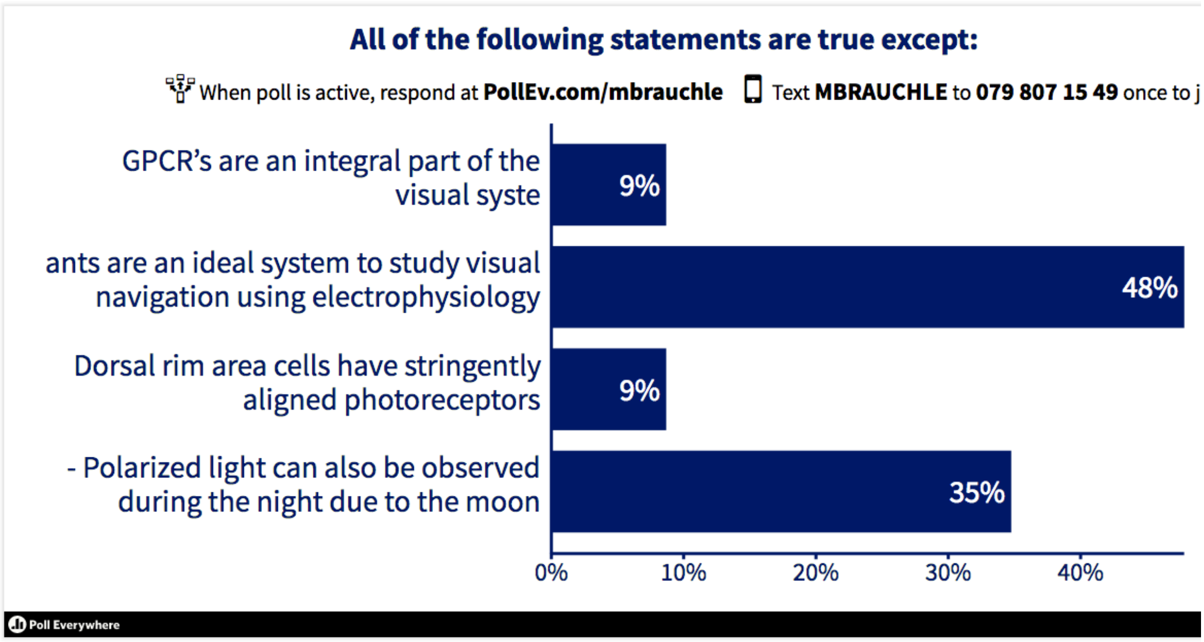
19. I would recommend doing this again in next year's course



20. Additional comments (also about M. Brauchle's lectures in general):
- well explained, pretty good
- thumbs up
- I was happy when you were giving the lecture in English because I don't understand anything when the teacher speaks German. So, it was really cool
- good speaker, interesting lectures!
- there should be more things written on the slides
- don't change anything, your lectures are my favourite, always well explained and interesting
- question with polleverywhere are very useful to understand the topic; in general, the lecture is interesting

Supplementary Figure 1: example questions and results from in-class Poll-everywhere questions





Supplementary Presentation 1:

Reading and presenting a research paper

Slide 1

Reading and presenting a research paper

Animal physiology course BL.0015 FS16

Slide 2

Why do we write and read scientific papers?

Scientific papers are at the heart of the science community: it's how scientists communicate.

- the most up-to-date information about a field
- contain information about how experiments were conducted

Reading and critically analysing primary research articles is a major part of being a scientist

The more you do it the better you become!

Slide 3

Our approach

Build groups of 3 (max4) people

Select a topic you are interested in from the lecture series
(there has to be at least one presentation per lecture)

select a paper to be presented in class
- find one yourself (has to be approved)
- select one of the suggested papers

Read the paper individually, meet as a group and discuss the paper.

Make the presentation (pdf or powerpoint)

Send the presentation by Wednesday night by e-mail for it to be uploaded on moodle

Guidelines for the Presentation:

Duration ~ 8 minutes
Slides in english but presentation can be in German or French

No more than 6 slides

Introduction	2 slides
Question	1 slide
Approach	1 slide
Results	1 slide
Conclusions and outlook	1 slide

The content will be used in the final exam (around 15 % of exam):

There will be one statement («correct or wrong») for each paper presentation.

Statements are only from the presentations, you do not have to read all the articles!

Slide 4

Do's and dont's....

... discuss the article in the group

... keep it simple: identify one key experiment and discuss it

... keep it general: make sure that your presentation can be understood by your (non-biologist) friends
(have a «20 minutes» story in mind)

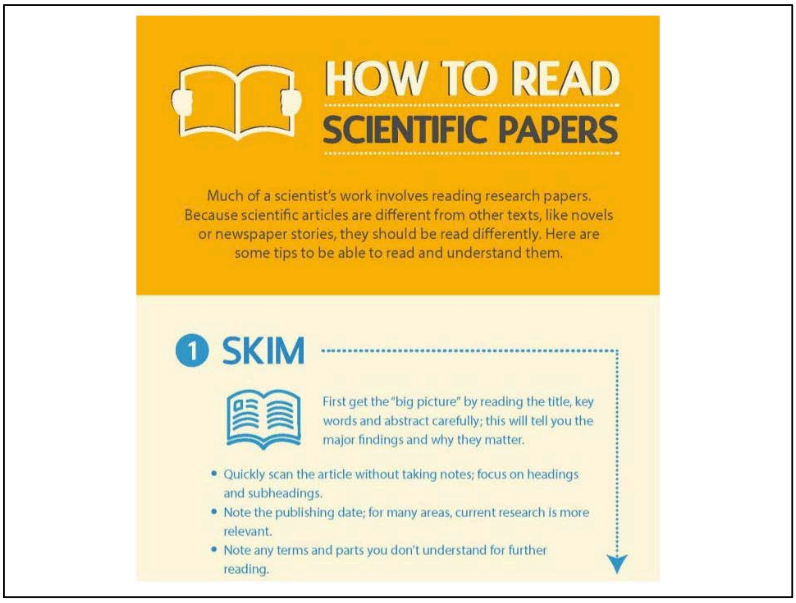
... use any specialist vocabulary, abbreviations

... try to understand all the detailed methods

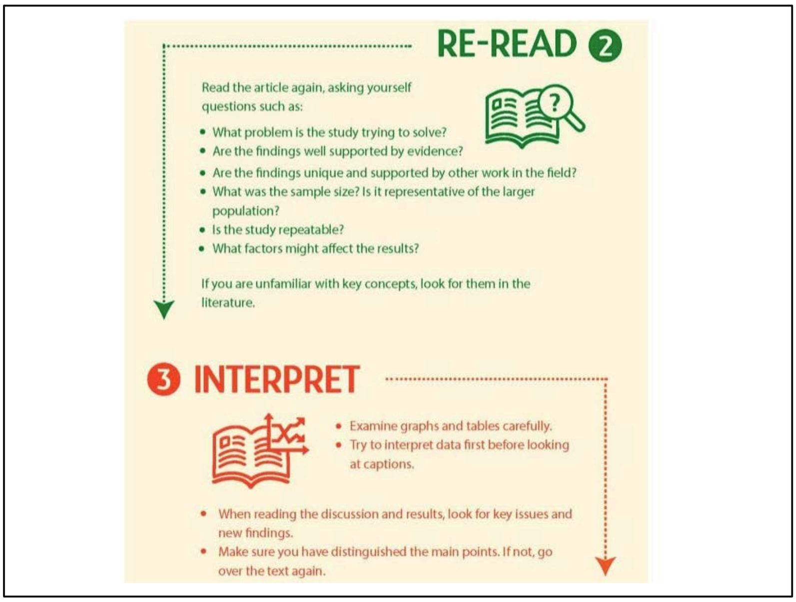
... summarize all the data

... get lost in the details...

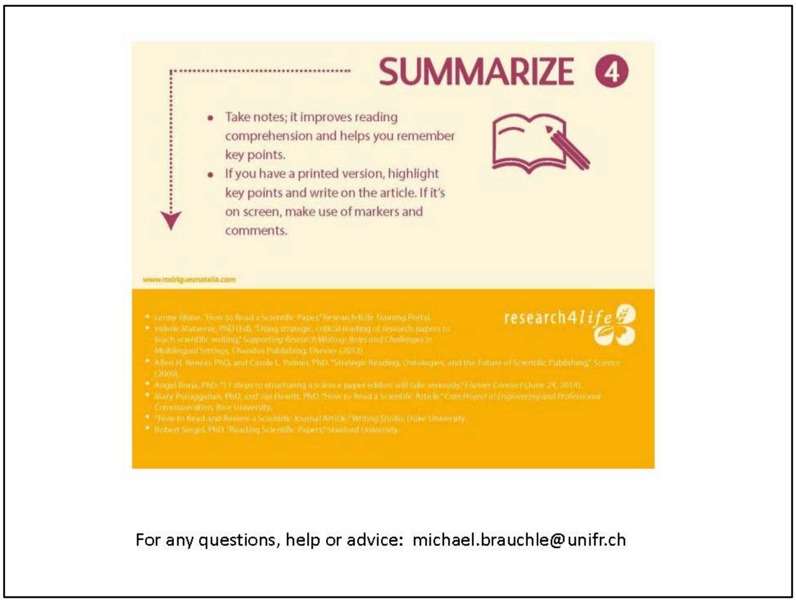
Slide 5



Slide 6



Slide 7



Slide 8

Supplementary
Presentation 2:

example research paper
presentation

An In-Depth Analysis of a Piece of Shit:

Distribution of *Schistosoma mansoni* and Hookworm Eggs in Human Stool

Stefanie J. Krauth, Jean T. Coulibaly, Stefanie Knopp, Mahamadou Traoré, Eliézer K. N'Goran, Jürg Utzinger

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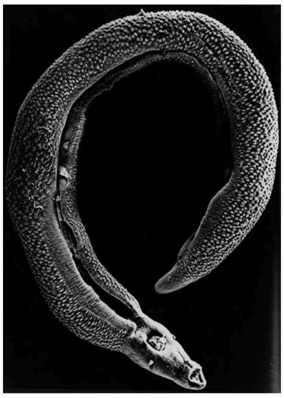
PLoS Negl Trop Dis 6 (12): e1969. doi:10.1371/journal.pntd.0001969

Slide 1

Background

Schistosoma mansoni



Loukas Nat Med 2008

Helminths (parasitic worms) are the most common infectious agents of humans in developing countries

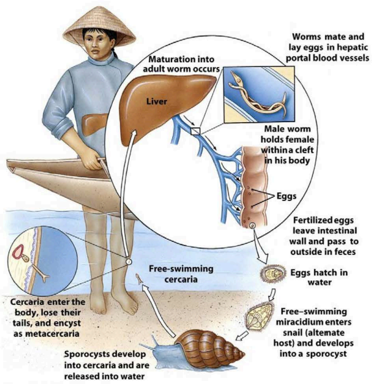
About 1/3 of people living on less than 2 dollars a day are infected

Schistosoma infect more than 200 million people and are responsible for 20,000 deaths per year

Slide 2

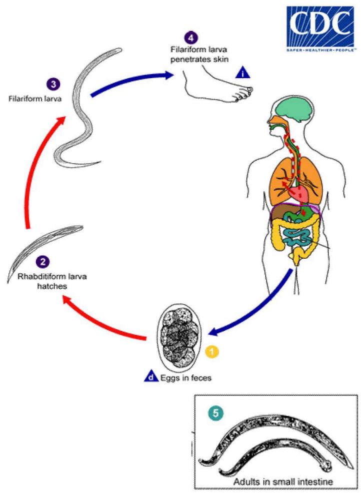
Schistosoma mansoni life cycle

Hookworm life cycle



150 um long

http://www.ppdictionary.com/



Slide 3

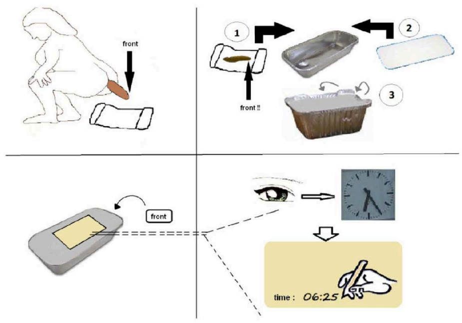
The Question(s):

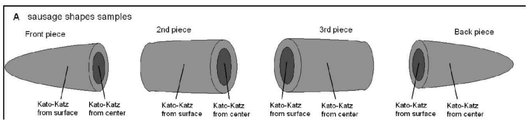
1) Do eggs of *Schistosoma mansoni* and hookworms display any particular spatial distribution in the piece of faecal matter?

2) Can we define a standard protocol (homogenize or not, and storage temperature) to guide future analysis leading to more accurate diagnosis?

Slide 4

The approach





Slide 5

The results

Egg Distribution along the Length Axis of the Stool

	n samples	Front piece (95% CI)	2nd piece (95% CI)	3rd piece (95% CI)	Back piece (95% CI)
S. mansoni	42	656 (372–940)	670 (346–995)	616 (349–883)	670 (275–841)
Hookworm	14	986 (149–1823)	396 (0–1040)	422 (0–1191)	267 (0–713)

S. mansoni eggs, as well as hookworm eggs, are equally distributed

Effect of Stool Storing and Examination of Time Delays on FecalEggCounts

Number of *S. mansoni* eggs showed no difference dependent on storage or time of analysis.

Hookworm eggs were found significantly less in samples analysed at later timepoints and/or stored at room temperature. However, no difference was found if the stool was stored under a wet towel or on ice.

Slide 6

Slide 7

Conclusions / Summary / Outlook

- Helminth Egg distribution looks to be similar along and across a stool sample
- A correct determination of hookworm eggs requires stool storage under wet conditions or on ice.

Introducing these simple measures will help to achieve more accurate estimations of FecalEggCounts and infection intensities in helminth diagnosis.

Slide 8

Statement for the exam

Please indicate if the following statements regarding the paper presentations are correct or wrong.

The paper analyzing helminth eggs in human stool claims that:

Eggs of helminth worms are equally distributed in human feces ______________

It is advised to store human stool samples in dry environments and overnight before stool analysis ______________

9. Acknowledgments

I would like to thank the many colleagues, including people I met during the didactic courses, that have discussed teaching aspects with me. It is a wonderful experience and a great opportunity to discuss the ways we learn and to help to create a learning environment be it in the classroom or outside. After all we never stop learning! Special thanks go to Prof. Simon Sprecher who supported my wish to embark on this journey and to Amanda Ochoa-Espinosa for her continued support throughout.