Transforming herpetology teaching in Animal Morphology through greater student engagement

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Student engagement and active learning in zoology teaching

Student active learning was defined by Børte *et al.* (2023) as a range of 'instructional approaches that actively engage students in their learning process through collaboration and discussion', as opposed to approaches that render students passive, such as lectures (Dahl & Troelsen 2015). It frequently implements cooperative or collaborative learning settings (i.e. interaction among students), often in problem-based learning approaches (Prince 2004). When correctly implemented, the resulting student engagement is associated with better performance in higher education (Carini *et al.* 2006; Harbour *et al.* 2015; Kahu & Nelson 2018). An enormous array of active-learning strategies in biological education has been catalogued (Driessen *et al.* 2020), but there are often barriers in the way of active learning (Børte *et al.* 2023) and lecturers frequently fail to effectively implement such strategies because they lack the pedagogical skills and training (Andrews *et al.* 2017). These issues are also deeply rooted in the epistemological history of teaching in the field (Børte *et al.* 2023).

Teaching in the field of zoology is traditionally associated with a combination of lectures and practicals. Although some lecturers have been so charismatic that their lectures gained popularity even among the general public, more average lectures delivered by typical lecturers are often highly technical, and it is not without reason that they are stereotypically portrayed as a monotone drone of incomprehensible jargon. It is all the more important, therefore, that they are offset with

practical, hands-on activities, which reinforce key concepts. Much of the teaching concerning comparative anatomy, for instance, is based on dissections, which allow students to contextualise images from textbooks or lectures based on their own experience with the anatomy. This is often crucial, because the context and especially colour of organs can differ among individuals, and only those experienced with dissections can establish the homology of organs that is so critical to evolutionary and functional analysis. Moreover, until recently, all such learning would have been based on two-dimensional illustrations of the anatomical structures, which fail to capture the three-dimensionality of the structures, quite aside from lacking the textures and other features that can be so insightful. In the age of increasing digital teaching, online video content can supplement that knowledge, but my colleagues and I have argued that it cannot replace it altogether (Ruthsatz *et al.* 2021); actual dissections remain an absolutely key component of the experiential training of competent zoologists.

As practicals are deeply embedded in zoological teaching, we might consider the field to already contain a balance of student active learning environments, and passive learning settings that reinforce and provide a structure to contextualise knowledge. However, because there is this reliance on lectures to provide the tools that allow students to contextualise their knowledge and achieve deeper understanding, including the ability to abstract and develop their own hypotheses, these need greater attention. When the student engagement and thus attention is high during practicals, but low during those critical lectures that link and build upon the practical knowledge, students may fail to acquire the tools required to go further in the field, and thus ultimately lack the understanding of key concepts required to proceed in the field in future years, or to pursue a career in or adjacent to this field (Andrews *et al.* 2017).

Here, I report on an attempted intervention in my own teaching as part of the University of Copenhagen's Master's Course 'Animal Morphology (from Sea Sponges to Vertebrates)', wherein I transformed my previous teaching from teacher-focused lecturing, to student-focused, engagement-rich lessons.

Animal Morphology (from Sea Sponges to Vertebrates)

Course framework

The Animal Morphology course is one of the flagship courses offered by the Natural History Museum of Denmark (NHMD), a department within the faculty of Science at the University of Copenhagen. The course has existed, under various names and structures, for over a century. Currently, it is an elective Master's-level course worth 7.5 ECTS points. It has a student capacity of up to 40 students, but enrolment is typically between 14 and 20 students. The pool of available students is ca 60 students each year (Biology Master's degree enrolment), so the course performs moderately well in recruitment, though at lower numbers than would be desired. The enrolled students are dominantly Master's students, although Bachelor's students can take the course, and occasionally some do. Currently, few students from other Master's programmes elect to take the course, but it is hoped that by advertising the programme to other students, we might increase recruitment from outside strict Biology.

Animal Morphology runs for eight weeks in Block 4, and consists of a series of lectures and practical exercises. Each lecture is on a specific group of organisms, spanning the diversity of animal life, 'from sea sponges to vertebrates'. Each week, nine hours of classes are held over two days, divided into three three-hour blocks. Teaching consists primarily of a mixture of lectures and dissection or examination exercises. Additional practical exercises typically consist of students using specialised equipment, such as a scanning electric microscope, although these practicals were not implemented in 2023. Teaching on the course refers largely to a single textbook, ISE Integrated Principles of Zoology (Hickman *et al.* 2019), and students are generally not asked to read primary literature for the course.

The stated Intended Learning Outcomes (ILOs) of Animal Morphology focus on the broad knowledge that students receive about animals of all kinds. They focus on equipping the students with the ability to describe anatomy and function across animals, and compare organs across different groups in order to understand things like convergence and homology—key concepts in evolutionary morphology. The stated

competence goals include equipping the students for other courses in biology and palaeontology, as well as other careers. As a result of a review by myself and other instructors, we are in the process of overhauling these ILOs to make them more explicit, achievable, and better aligned with the teaching that takes place on the course. These changes should take effect from 2024 onwards.

The assessment of student learning in the Animal Morphology course is done via an oral exam. Exam sessions are held with pairs of instructors present, each of whom examines on their particular taxon of expertise, while the other acts as censor. Students are presented with a choice of face-down A4 sheets, each of which has a set of questions and illustrations that act as the framework for the oral exam. In many cases, physical objects (specimens) are also brought to the exam by the examiners, and these can either form the basis of exam questions, or can be used by the students to support their answers.

Until 2022, the students were examined on only one subject for 20 minutes. This format has advantages and disadvantages. On the one hand, a student's deep knowledge on a given taxon is tested, which is well aligned with the teaching approach taken across the course, i.e. one that focusses on each taxon more or less in isolation, without lectures that link across the taxa. The examiners are able to assess students' performance against the specific ILOs of their own classes. On the other hand, this does not assess the students' performance against the broader course ILOs specified in the course description. This means that the students' ability to integrate knowledge that they gained across the whole course is not assessed. It also disadvantages students who might not have been able to attend a given lecture, or whose understanding of a specific subject may not be representative of their understanding across the course as a whole, or of other groups.

In 2023, we revised the exam style of the course: instead of examining students on just one subject for 20 minutes, we examined each student on two subjects, each for ca 10 minutes, plus 10 minutes for administration, discussion, grading, etc. This meant that student exam success no longer hinged on a single subject, with the idea being that this should in principle be better for students who are weaker on one subject than another, and that we would be better able to assess overall student

knowledge and learning better based on the two components, than based on a single component.

Herpetology in Animal Morphology — Paradox: good feedback, poor exam performance

Until 2021, lectures on reptiles and amphibians (herpetology lectures) were taught by Prof. Morten Allentoft, but in 2022, I took over this component of the course. As the Curator of Herpetology of the Natural History Museum of Denmark, I am very well equipped to instruct on this subject. In 2022, the herpetological component of Animal Morphology was a single three-hour session, wherein I covered amphibians and reptiles and some background on their evolution and relationships, also with other vertebrate groups (mammals, birds, fishes). My teaching in 2022 consisted of lectures in a rather traditional format, with only occasional questions asked to the audience, followed by a dissection of a selection of reptiles by different groups of students. The teaching is *research-informed* (Griffiths 2004), being based on the latest research on the subject, but not pushing the students to read primary literature or conduct their own research.

The feedback I received on this teaching was very positive; this can be best summarised by the written feedback given by the students, such as ‘Brilliant! Have a energy and passion about his teaching, by far one of the best lecturers I have had’ and ‘Really fun and easy to follow!’ One student wrote ‘GIVE THIS MAN MORE TIME!!! At least he should be given two separate lectures for which he can talk about Amphibians and Reptiles fully. His is very good and funny to be lectured by :)’.

Given this excellent feedback, it was surprising that the student performance in the exam was very poor. I examined three students, and acted as censor for four students on another subject. The students I examined performed very poorly on average; two received a low grade (2 or 4), and one failed (0). By contrast, those students examined by the colleague for whom I acted as censor performed substantially better, with several 10–12 marks. This raised several questions: why did the students I examined perform so poorly in comparison to their colleagues examined on another group? Was this a result of my teaching style and lecture

content? Or was it simply chance; that the students I examined would not have performed well on any subject, but happened to be examined by me?

Intervention: improving didactical and pedagogical approaches to enhance student learning and performance

In order to improve my teaching, aim to increase student performance, and also improve pedagogical and didactic approaches in my teaching built on training in the University Pedagogy course, I undertook a major overhaul of my teaching on the Animal Morphology course in 2023.

Doubled teaching

The course organiser took onboard the feedback of the student who asked for separate sessions on reptiles and amphibians, and I was given two three-hour sessions, which I divided over these groups. This gave me substantially more time to deepen the teaching, but also to employ a greater variety of didactical/pedagogical approaches in my teaching. In conversation with the lecturer who was presenting on birds, I decided to alter the scope of my teaching somewhat, to ensure that I covered all tetrapods, including the dinosaur/bird lineage up until the modern birds. This was important, because there is currently no other session on tetrapods as a whole. Moreover, there are no mammal lectures in the Animal Morphology course, and so I included basic information about mammals and their evolution in my lectures as well.

Student activation and engagement

I employed several new student activities, in order to achieve deeper learning objectives and increase the amount of activation among the students. I divide the kinds of activities I engaged in into six categories:

(1) Individual activities (e.g. having students identify particular anatomical structure, Fig. 1a) followed by group discussion of the results. These were used predominantly to assess student knowledge, and to activate the students.

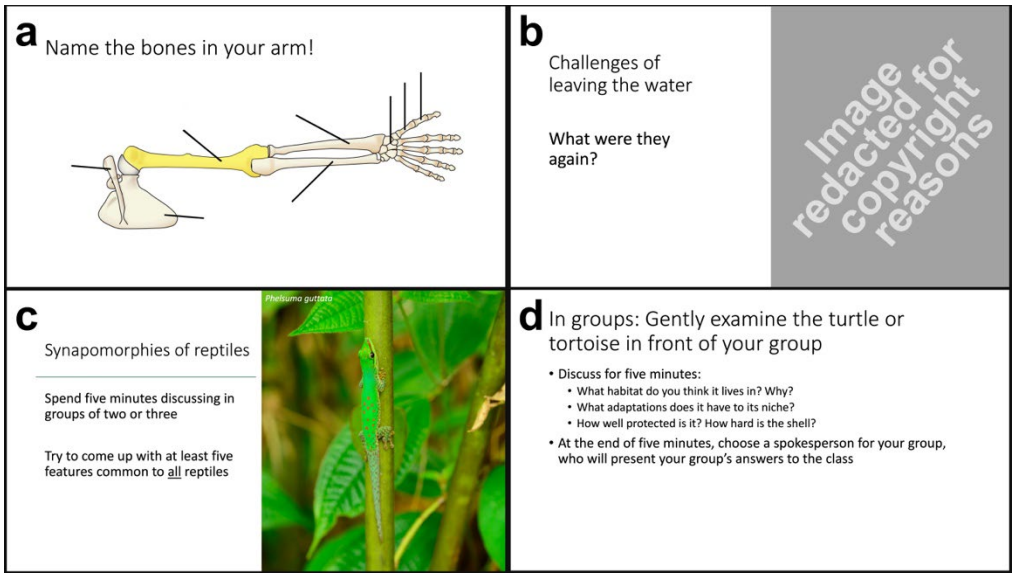

Fig. 1. Examples of slides used for student activation in my intervention in the Animal Morphology course in 2023. (a) An activity with a handout given to all students, where they were asked to label the bones of their own arm. (b) Interactive learning recall from the last lecture. (c) Group discussion prompt that was followed by answers written on the blackboard. (d) Group specimen examination followed by brief presentation by each group.

(2) Open questions to the students (e.g. asking about possible challenges that face organisms when they are evolving to leave the water). These were used predominantly to assess student knowledge and stimulate discussions. They also encouraged students to use deductive reasoning, which is important in this subject area.

(3) Interactive learning recall (e.g. asking students about things we had covered in the previous lecture, to ensure that the knowledge had been retained, Fig. 1b). This was mainly done to reinforce learning from previous sessions.

(4) Group discussion followed by volunteered answers to open questions, which I wrote up on the board (e.g. Fig 1c). This encouraged discourse and active participation in the learning activity, as well as pushing students to draw on their existing knowledge and share it.

(5) Group examination of specimens and discussions about them, followed by brief presentations to the class about the specimens (Fig. 1d). This also encouraged discourse, deductive reasoning, and student activation, as well as encouraging the development of on-the-spot presenting skills.

(6) Individual dissection of frog specimens. This more classical component reinforced learned anatomical knowledge, and gave the students a deeper understanding of amphibian anatomy, and procedures in dissection. It also served to challenge their own understanding and expectations, because it stimulated them to identify and puzzle their way through the anatomy of the animal.

Altogether, student activation took up a major part of the lesson time, cumulatively about 25% of the six total hours.

Assessment of intervention impact

In order to qualitatively and quantitatively assess the impact of the intervention, I assessed success based on four areas: (1) my own perception of student engagement level and classroom environment. This is the most subjective criterion, and the most difficult to reflect upon, because of the challenging duality of teaching and observing that leads so easily to warped impressions. (2) Feedback from students (ratings and written feedback). To enhance the detail in feedback from students, I added two questions to the feedback form: 'Did you find the interactive elements of the herpetology lectures (discussions, presentations) useful?' and 'Did you find the practical elements of the herpetology lectures (dissection, specimen examination) useful?'. These were assessed based on a five-point rating scale (Very bad, Bad, Satisfactory, Good, Very good). (3) Student performance in the exam. (4) External feedback. I had two rounds of external supervision: by two peer supervisors on the first of my post-intervention lectures (ca 45 minutes), and by two pedagogical supervisors on the entirety of the second of the two post-intervention lectures (3 hours). Both groups provided oral and partly written feedback on the teaching they observed.

Results of intervention

My perception

I perceived the changes to my teaching, both in terms of increased contact time and newly employed didactical/pedagogical tools, to be greatly beneficial for the students. Participation in discussion and activities was lively and seemed highly motivated, and I did not have the impression that any student was bored or disinterested. I was able to achieve active contribution by all or almost all of the students. In contrast to my teaching in 2022, this was a dramatic change, given that I had had so few interactive elements before. Moreover, in my 2022 teaching, I had the impression that vocal participation and answering of questions was dominated by a select few individuals, whereas in the post-intervention teaching, almost all students participated vocally at least once, and all students were able to be activated in the discussion groups.

One downside to my post-intervention teaching was the balance of time given to each subject, and the overall time management. Several sessions ran slightly longer than anticipated, and as a result, later parts were rushed. This was particularly noticeable in the frog dissection, where students wound up spending so much time examining their frogs externally, that there was too little time for a thorough dissection to take place. In future, it will be necessary to revise the timing, to ensure that at least 80 minutes are set aside for this dissection, rather than the ~50 that were available.

Feedback

Student feedback on my teaching in 2023 remained excellent, and may have been slightly better than 2022; for example, one student wrote ‘One of the best lecturers I've had in this university. Super enthusiastic and interested on what the students get from the class. His classes were very interesting and easy to follow’ and another wrote ‘An absolutely amazing teacher! His energy is fantastic and you really want to listen to everything he says.’ (translated from Danish). The more interactive format of the teaching was appreciated; one student wrote ‘Very good teaching and really interesting to listen to him. There were lots of other activities than

just lecturing, this made it possible to maintain interest and concentration much better. He was very good at including us in the lessons and was not judgmental if you said something stupid,' (translated from Danish).

In response to the question of whether students found interactive elements of the herpetology lectures (discussions, presentations) useful, 84.6% (11/13) of students responded that they found them 'very good', and one each found them 'good' or 'satisfactory'. In response to the question of whether students found practical elements of the herpetology lectures (dissection, specimen examination) useful, 69.2% (9/13) of students responded that they found them 'very good', 3 found them 'good', and one responded 'satisfactory'. It is likely that the students responding less enthusiastically to the latter question reflected the fact that the frog dissection was so rushed.

In summary, student feedback remained very positive, and students were vocally in favour of the more interactive/engaging approach to teaching that I took in the intervention.

Student exam performance

As a result of our changed examination format, five students were examined on herpetological questions in 2023, in contrast to just three in 2022. Overall student performance was good; two students received a 12, one received a 7, one received a 4, and one received a 2. We were able to balance the mark between the two subjects that the students were examined on, and in one instance, this was significant, because the student performed substantially better on one subject than the other. As a non-Danish faculty member who is not accustomed to oral exams, I also found it very useful to have a more frequent hand-off between myself and the other examiner, to improve the way that I examined the students. These factors support the keeping of this revised exam format. I had the impression that the increase in teaching content, as well as the pedagogical development carried out on the classes, increased the depth of understanding among the students, and contributed to the overall good performance in the exam.

Peer and formal feedback

Feedback from my peer supervisors on the first lecture was very positive. Regarding student activation and engagement, they noted the students seemed to be active throughout the lecture, taking notes and answering questions. Not all students participated vocally during the session they observed, but they were nevertheless engaged in activities. The rest of this session, which was not observed, included the frog dissection, where all students were activated, and most asked questions.

Feedback from my pedagogical supervisors on the second day was also very positive. They found my pedagogical approach to be strong. They appreciated frequent questions to the students and interaction with them. They highlighted that my enthusiasm for the subject matter spills over to the students, helping to inspire and energise them. However, they also provided constructive suggestions for future lectures on this course. In particular, they recommended that I focus on what students should do in order to achieve the Intended Learning Outcomes of the courses, and suggested that I might provide handouts that students could fill in as more information was supplied about the subject matter.

Discussion

This intervention in my teaching on the Animal Morphology course showed that a more interactive teaching approach, fostering greater student engagement and encouraging student active learning, elicited strong student satisfaction, improved overall performance of students, and was also approved of by peer and academic supervisors of my teaching. This is in keeping with a wealth of literature on student active learning across disciplines (Børte *et al.* 2023; Driessen *et al.* 2020).

Although the intervention had the desired outcomes, it is worth mentioning two particular caveats. In my perception, the extent of interactivity in my lesson planning came at the cost of (1) substantially increased preparation time, and (2) much reduced time to attempt to teach more detailed information about respective taxonomic groups I focused on. I will elaborate on these here.

(1) As might be expected, changing lesson structure and building in new elements required a great deal more preparation time than my teaching in this course in 2022. This was particularly extended because I

lacked the previous with such interactive approaches, and consequently had to spend several hours coming up with possible interactive or engaging activities for the students. As is typical with teaching preparation, there is clearly an element of this preparation that will not need to be invested again in future years. However, some elements of the revised approach, such as the use of specimens from the zoological museum for the teaching, will require the same amount of preparation time every year. I estimate that this has increased the overall preparation time in future years by at least 30%.

(2) Animal Morphology is a highly fact-based course. The aim of the Animal Morphology course is to provide students with a strong foundation on the anatomy and diversity of all major animal groups. This lends itself to rote learning in some cases, although deeper learning objectives certainly require the students to make connections among pieces of information and think more deeply about the organisms. Of course, it is not possible to give students a *comprehensive* picture of the anatomy and diversity of each group, because doing so would in many cases require several dedicated courses of their own. There is consensus that we should treat all major taxa to some degree, but how deep we should go on each taxon is not established or standardised. Some groups are treated in great detail, while others (e.g. mammals) are hardly treated at all.

A balance must be struck between the transfer of information to the students that gives them this deep and broad knowledge of animal diversity that we are striving for, and reinforcement and networking of that information to help the students to be able to appropriately wield, contextualise, and interlock that knowledge, which will be important for them if they wish to work in a field where these abilities are important.

Between 2022 and 2023, the number of teaching hours I had on the Animal Morphology course doubled. In principle, this should have enabled me to incorporate substantially more information into my teaching, and thus have the 2023 students come away with a more comprehensive knowledge of reptiles and amphibians than the 2022 cohort. In practice, however, my post-intervention teaching in fact contained *less* overall information than the 2022 teaching. This is because the target of interactive, engaging, student active learning activities was

focused on those activities that would reinforce points, encourage dialogue amongst the students, or solicit inductive learning. These activities consumed substantial amounts of time. Consequently, more engaging lessons came at the cost of the rate of information flow. However, it is my impression that it did increase student comprehension of the information compared to the previous cohort, and thus, if I consider the level of information in 2022 to be adequate for this course (which I do), the change to a more interactive and engaging approach had a net benefit to the students.

Caveats like these may be contributing to the poor level of overall adoption of these methods by teachers in biological sciences, as documented by Andrews *et al.* (2017). However, I consider the post-intervention teaching to have been a strong improvement on previous teaching, as documented based on both qualitative and quantitative metrics. Consequently, I have made similar changes that increase student active learning and engagement to other courses I teach on at the University of Copenhagen.

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