

Course segment redesign: Practical exercises with live animals

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Introduction

A competency after graduating from the Animal Science programme at the University of Copenhagen is to be able to link theory and practice for the sustainable use of animals for the benefit of humans and animals. To this end, graduating students are expected to acquire basic knowledge about quantitative biology including the relevant methods, while acquiring the ability to critically evaluate research and results. The foregoing involves learning how to analyse problems through a holistic insight into the relationship between the structure of the body, its functions, its ability to perform as well as its welfare and surroundings.

Different teaching and learning methods such as lectures on key points, seminars, problem-based learning, laboratory demonstration, and practical exercises are used to ensure students achieve the goals. However, decreasing university funding and money-saving procedures present challenges concerning what can be done for practical work. For instance, for the last 2 years, it has been rather difficult to do demonstrations on quantitative energy and protein metabolism in one of the segments of a master level course within the Animal Science programme since the research farm was phased out due to the cutback. Further, no ongoing research project and shortage of staff have presented a challenge in conducting practical exercises for this segment. To address this issue, students are taken on a tour to the defunct university research farm to see the facilities and explanation provided on the operation on each piece of equipment. However, one of the criticisms regarding course alignment, in the recent student course evalu-

ations, was with this segment, whereby a majority of the students thought the field trip to see the research facilities is a waste of time if no real activities are going on (Course evaluation, 2020). Thus, suggesting discord between the intended learning outcomes (ILOs) and teaching and learning activities (TLAs) for this segment due to the disconnect between its lecture and practical exercises. One can question whether visiting nonfunctional research facilities to see previously used equipment translates into learning the necessary practical skills to operate that equipment. Therefore, it was imperative to include a cost-efficient and easy-to-conduct animal experiment in the practical exercises to get the segment more interesting and for students to learn more from the practical exercises thereby strengthening the overall congruence (between ILOs and TLAs) for this segment. Thus, the objectives of the project reported herein were to (i) provide students a cost-effective practical exercise involving live animals to provide hands-on experience, (ii) motivate them via the new practical activities to ensure they achieve the ILOS, and (iii) increase the overall relevance of the course and make it more beneficial to students with regards to the real-world.

Methods

Context and Course description

The intervention was carried out for one of the segments of the course “*Experimental Animal Nutrition and Physiology*” (EANP), where the course evaluation from previous students has suggested a redesign of the practical exercises to further strengthen the alignment and congruence between teaching elements. The EANP is a full degree master course offered for students in the Animal Science programme and is designed to introduce students to experimental techniques commonly used for assessing functions and nutrient metabolism at the whole-animal and organ levels (Course description). Students are introduced to the principles required for planning and implementing *in vivo* or *in vitro* experimentation and how to critically evaluate the results from such experiments. The course also has elements that make it possible for students to fulfill the educational requirements of an EU directive and the Danish National Authority, “Dyreforsøgstilsynet”, for persons working with experimental animals or assisting in animal experimentation (Course webpage). Within this context, students are expected, among other ILOs, to be able to describe; (i) the principles behind specific

methodologies for animal experimentation, (ii) the methods for measuring digestibility in different segments of the digestive tract of livestock animals, (iii) the appropriate experimental designs and statistical approaches used for specific methodologies, and (iv) the relevant legislation, handling, and management of laboratory animals. Three TLAs are used to ensure students achieve the ILOs. Thus, (i) lectures to present theories on principles, experimental design, and techniques for conducting animal research, (ii) theoretical exercises for students to summarize laboratory-generated data and interpret their findings using the theories from lectures, and (iii) laboratory demonstration and practical exercises on live animals, depending on the course segment.

Description of the intervention and activities

The segment, in which the intervention was carried out deals with quantitative energy and protein metabolism in livestock and companion animals. Two other teachers and I carried out the project described herein. This year, the goal of this segment was to provide more hands-on experiences for students. Therefore, the decision was also to re-design the lecture session to focus more on the practical parts, i.e., the theory and application of the different methods for quantitative measurements of energy and nutrient metabolism. To be cost-efficient, the practical exercise was moved to the Frederiksberg campus. Four pigs were bought through the Department of Experimental Medicine and housed in one of the animal stables on the Frederiksberg campus. The pigs were used to introduce the students to animal handling during experiments following research protocols. They were also used for demonstrations on how to use stable isotope methods to study energy metabolism (based on carbon dioxide measurement via gas mask) and how to conduct a nutrient balance experiment to determine energy and protein metabolism in live animals.

Seventeen, out of the 18, students who enrolled in this course participated in the practical exercise. The students were divided into 4 groups and each group carried out the carbon dioxide measurements using a gas mask and the sample collection for the nutrient balance experiment. At the end of the practical exercise, students were provided with 10 standard survey questions (Appendix A) to complete. Seven questions required responses based on a linear scale (1 to 5, strongly disagree to strongly agree) to collect quantitative data, and 3 questions required respondents to provide short responses (qualitative data). SurveyXact was used to create the survey and

the link was distributed to the students to complete anonymously. There was also an open-discussion session at the end of the segment for students and teachers to discuss their impressions or thoughts about the TLAs and ILOs of the segment along with ideas and suggestions for future segment planning.

Results

Twelve out of the 17 students who participated in the practical exercises completed the survey questions giving a response rate of 71%. It should also be noted that one respondent corresponds to approximately 8% of the total respondents of a survey question presented in what follows.

The first 2 questions requested students' general opinions on practical exercises. Here, when asked if they gain a deeper understanding through practical work than through lectures, nearly all the respondents (50% strongly agreed and 42% agreed) at least agreed, whereas 8% indicated neither agreed nor disagreed (Figure 1). Further, 75% strongly agreed, while 17% agreed that practical exercises allow them to participate actively in class. (Figure 1) Two of the questions to collect quantitative data were

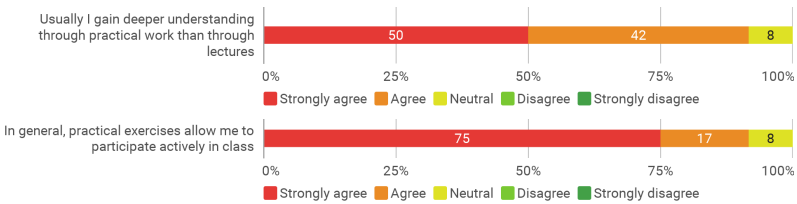


Figure 1. General opinion on practical exercises.

Almost all the respondents at least agreed (58% strongly agreed and 33% agreed) that the learning objectives for the practical section were aligned with the practical activities carried out (Figure 2). Concerning alignment between course elements, all the respondents agreed (75% strongly agreed and 25% agreed) there was a good connection between the practical exercises and the lectures (Figure 3). It was also apparent that the students appreciated the need to have a hands-on experience on methods discussed

in the lecture section. For example, one student indicated, “*It was nice to try the methods explained during classes, as I feel I have a much better understanding of how to conduct the methods now*”. Another student commented, “*I gained a better understanding of the different experiments used to determine protein and energy metabolism in domestic animals*”. Another 2 students commented, “*I have gain knowledge on how the experiment is carried out and I have gain knowledge on how to handle the animals*”, and “*The practical demonstrations really give a better understanding of all the work that is put into such experiments*”.

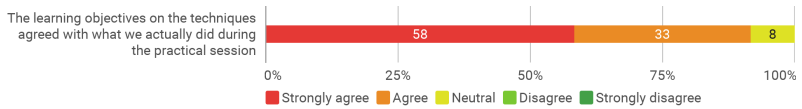


Figure 2. Alignment between learning objectives and practical activities.

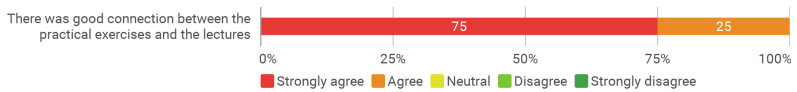


Figure 3. Alignment between teaching formats.

All the respondents agreed (75% strongly agreed and 25% agreed) that they had a good interaction with the teachers during the demonstration and asked questioned whenever necessary (Figure 4). One student commented, “*Everything went smoothly. The professors answered all my questions regarding specific parts of the theoretical/practical parts*”. Regarding teachers’ enthusiasm, a majority of the students also agreed (83% strongly agreed and 8% agreed) the teachers appeared passionate and helpful during the practical exercises (Figure 5), whereas 8% indicated neutrality when responding to this question.

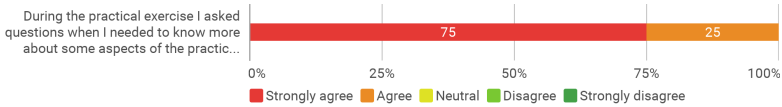


Figure 4. Interactions during practical exercises.

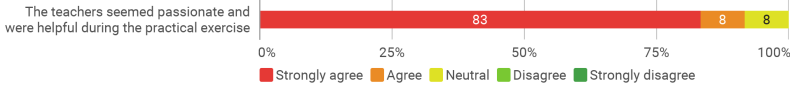


Figure 5. Teachers' enthusiasm during practical exercises.

Regarding the question on students' general impression of the practical exercises, 67% strongly agreed and 25% agreed the practical session went well (Figure 6). Examples of some of the comments from the students are “*I learned how to make breath tests with live animals and how to handle animals during experiments*” and “*I especially liked the breath trial because I had the feeling of doing an entire experiment [.....]*”. However, 8% of the respondents neither agreed nor disagreed on whether the practical session did go well (Figure 6).

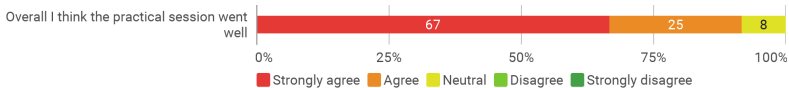


Figure 6. Overall impression of the practical exercises.

What have you gained from this practical exercise?

Here, all the students answered that they have gained knowledge on how to handle animals for experiments and understanding of the techniques that were discussed during the lecture session. For example, one student mentioned, “*More knowledge about how to handle animals (especially pigs) when using them for experiments. And also how important it is to not have a stressed animal*”. Another student commented, “*I have gain knowledge on how the experiment is carried out and I have gain knowledge on how to*

handle the animals". Other comments such as "*I understand the methods better now*", and "*More knowledge about the two methods we tried. For example what the methods are used for and which advantages and disadvantages there is with the trials/methods*" were also made.

What did not work well for you?

Most of the students mentioned that they had some challenges getting breath samples from the animals. For example, one student commented that "*Getting the breath samples was not easy, but that was due to the pig being stressed*", and another "*The breath test was a bit difficult to do, because the pig was not trained so well, so we were not able to get all samples*". This is natural when an inexperienced person attempts to obtain samples from experimental animals for the first time and had little to do with the practical exercise set up. Indeed, one student commented, "*A little more time with the pigs before handling them for the actual trial, could perhaps make it easier to collect samples*". Another student mentioned, "*my group was confused on how to collect some to collect the [.....] it would have been nice to get a "check" from the supervisor to see if it was done properly*" and commented further saying "*But of course we could also have asked*". Another student also commented, "*It was a bit chaotic when all groups were in the process of labeling the different containers for collection and lab samples during the balance trial demonstration*" and another mentioned, "*there were too many people present in the animal stable in the same time [.....] it was difficult to hear the instructions from the teachers*".

What would you change or suggest for improvement?

One student mentioned that more time with the animals before handling them for the actual trial could make it easier for them to collect samples. This was also the main topic for discussion during the open-forum discussions. Some students also felt the manual for the practical exercises was not thorough enough and need to be revised for the future. For example, one student mentioned, "*The manual for the balance trial demonstration could have been more thorough in describing[.....]. It would have been nice with an exact description of all materials needed*" and another commented, "*It would be nice to get a more detailed description of how the theoretical exercise [...]*". Finally, some students mentioned that it

would be nice to have carried out the laboratory analysis and used the results for the calculation/theoretical exercises and another student suggested the number of animals should be increased for the practical exercises. The latter 2 suggestions were also discussed during the open forum and it was agreed that would be difficult to implement due to time and expense.

Discussion

Learning science should not be a passive process, but rather an active one. It is, therefore, not adequate that science students learn only theories and understand the relevance of those theories. They should also learn how to put theories and concepts into practice. This will help them gain a deeper knowledge of theoretical concepts and increase their ability to see and understand technical things in a larger context (Millar, 2004). The foregoing concurs with the results of this project, where the students agreed to have gained a deeper understanding through the practical work. Further, the current findings confirm how students appreciate hands-on experiences through practical exercises and how they find them extremely beneficial. The comments regarding what students gained from the practical exercises also confirm how students are more than willing to be engaged and actively participate in their learning through interaction with their teachers instead of being “spoon-fed” with information. These comments are also consistent with the report of Prince (Prince, 2004), indicating that engineering students prefer to be engaged in their learning and that this strategy increased their memory of course content and promoted critical thinking.

In this study, 8 % of the respondents (representing 1 student) neither agreed nor disagreed when answering questions on impressions about practical exercises in general and the current practical exercise. Reasons for this finding are not apparent because all the students who completed the questionnaire provided positive feedback when they were asked to comment on what they gained from the practical exercise. It is also not clear if it was the same student, who provided a neutral response to questions on impressions about practical exercises. Nonetheless, it has been reported that not all students find research-based teaching beneficial, especially students who prefer a surface approach to learning (Dohn & Dolin, 2015). In conclusion, the practical exercise introduced in this segment was successful in helping the students achieve the ILOs. The findings also offer support to the need for research-based teaching in higher education.

References

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A Survey questions

1. Usually I gain deeper understanding through practical work than through lectures

Strongly agree Agree Neutral Disagree Strongly disagree

2. In general, practical exercises allow me to participate actively in class

Strongly agree Agree Neutral Disagree Strongly disagree

3. The learning objectives on the techniques agreed with what we actually did during the practical session

Strongly agree Agree Neutral Disagree Strongly disagree

4. There was good connection between the practical exercises and the lectures

Strongly agree Agree Neutral Disagree Strongly disagree

5. During the practical exercise I asked questions when I needed to know more about some aspects of the practical exercise

Strongly agree Agree Neutral Disagree Strongly disagree

6. The teachers seemed passionate and were helpful during the practical exercise

Strongly agree Agree Neutral Disagree Strongly disagree

7. Overall I think the practical session went well

Strongly agree Agree Neutral Disagree Strongly disagree

8. Describe what you have gained from this practical exercise and your reasons

9. Describe what did not work well for you in this practical exercise and why

10. Describe would you change about this session or suggest for improvement

B

Commentary on knowledge gained from the practical exercises

Describe what you have gained from this practical exercise and your reasons

1. A good understanding of handling of smaller pigs when doing trials with them, and what the outcome of the trial is good for.
2. More knowledge about how to handle animals (especially pigs) when using the for experiments.
And also how important it is to not have a stressed animal.
3. Try to work in real life with the animals, that was really Nice to do in this course.
4. I gained a better understanding of the different experiments used to determine protein and energy metabolism in domestic animals
5. I gained practical knowledge next to the theoretical knowledge gained from last class.
6. I have gain knowledge on how the experiment is carried out and I have gain knowledge on how to handle the animals
7. More knowledge about the two methods we tried. For example what the methods are used for and which advantages and disadvantages their is with the trials/methods.
8. It was nice to try the methods explained during classes, as I feel I have a much better understanding of how to conduct the methods now. Even when preparing the materials, it got more clear why we should have the different steps and what we investigate in the different steps - and much easier to remember when discussing these methods later on.
9. The practical demonstrations really give a better understanding of all the work that is put into such experiments.

I especially liked the breath trial because I had the feeling of doing an entire experiment from the preparations of the ^{13}C -bicarbonate for oral ingestion, labeling the breath bags, taking the breath samples and watching them get analyzed in the lab with the infrared spectrometry and discuss with the teacher how the results are actually used.

I think we also gained a good understanding of how important it is to train the animals well before the beginning of a trial in order for sampling to be as easy as possible and avoid stressing the animal which could affect the results of such a trial.

10. I learned how to make breath tests with live animals and how to handle animals during experiments. It was nice to actually make the balance cage experiment ourselves instead of just read about it, because it gives a better understanding on all the requirements for that kind of experiment.
11. I understand the methods better now
12. I gained knowledge about how to handle experimental animals. Being calm and understanding for the animal

C

Commentary on aspects of the practical exercise that did not work for students

Describe what did not work well for you in this practical exercise and why

1. Getting the breath samples was not easy, but that was due to the pig being stressed.
2. My group had a misunderstanding of how to collect the feces and afterwards the "cleaning sample", maybe it would have been nice to get a "check" from the supervisor to see if it was done properly. But of course we could also have asked.
3. Nothing I can think about
4. There could have been some better communication between students and lecturers
5. Everything went smoothly. The professors answered all my questions regarding specific parts of the theoretical/practical parts.
6. Everything about the practical exercise worked for me
7. I would have liked to use the samples from the animals more, however, I know it is expensive and that it depends on the animals --> if they deliver a sample or not ;)
8. I think some of the things we investigated was a bit complicated. I mean the methods were easy enough to conduct, but I am still not comfortable with the theory behind for instance the isotope-breathing methods.
9. It was a bit chaotic when all groups were in the process of labeling the different containers for collection and lab samples during the balance trial demonstration because only some of it were actually mentioned in the manual and some of it were just told by the teachers.

I think the balance trial demonstration seemed a bit unfinished. I really liked the part in the stable where we got the understanding of how to practically work with the animals and the balance cages. But after we had collected the samples that was sort of it and I missed a better ending to the demonstration.

10. The breath test was a bit difficult to do, because the pig was not trained so well, so we were not able to get all samples. I did however understand the method, so it was not too bad.
11. xxx
12. The amount of people

D

Student suggestion for further improvement of the practical exercises

Describe would you change about this session or suggest for improvement

1. A little more time with the pigs before handling them for the actual trial, could perhaps make it easier to collect samples.
2. I don't really think there is that much need for improvement as it gave a good insight in how to use the method we have discussed during the segment.
3. Nothing I can think about
4. I believe we were too many people in the stable at the same time. It was difficult hearing the instructions at times because of noise from other students. Moreover there was some misunderstandings about how to collect the samples from the balance trial, so we did some minor mistakes that would have been good to know about beforehand.
5. If there are more animals to work on, the teams can get cut down to 2-3 people and the practical part will be absorbed better as a learned technique.
6. It would be nice to get a more detailed description of how the theoretical exercise was calculated either before hand (on Tuesday) or earlier on Thursday
7. More general information about the theoretical exercises. On the other hand, I know that we are going to talk about the results from these on Tuesday.
Generally, it was a very good day!
8. It would have been nice to use our own results and make calculations on those instead of the pre-given during the exercises. Just to get that last understanding from for instance the balance trial.
9. The manual for the balance trial demonstration could have been more thorough in describing what needed to be done during the preparations. It would have been nice with an exact description of all materials needed.

After the collection of samples in the balance trial I think it would have improved my further understanding if we had talked more about what happens with the samples in the lab. I am aware that we probably would not have the time to do the actual lab analyses but for example the teacher could have showed us the lab equipment used to analyze the samples and give us a chance to talk a bit about that. I think this would also give a better connection to the theoretical exercises where we used results from a balance trial to calculate N-balance.

10. I like the session how it is. It was nice to have lectures on the methods and then do them in practice ourselves. The teachers were good at helping out with handling the animals and collecting samples.
11. Allow the students 15 mins to reread the instructions for the experiment
12. Maybe a little more clearer introduction