How to teach Animal Breeding and Genetics to undergraduate students: presentation of a thinking process

E. H. van der Waaij¹, D. E. Lont¹, and H. A. Mulder¹.

¹Animal Breeding and Genomics Centre, Wageningen University, Wageningen, the Netherlands

ABSTRACT: We have been updating our undergraduate course in Animal Breeding and Genetics (study load of 6 ECTS). In this paper, we would like to share the thinking process, present some of our first experiences with teaching the updated course, and present some of our wishes for additional features. We were aiming to teach the students such that in their future career they would still have a fair idea about what is animal breeding. Our aim was to present the questions that arise in running a breeding program, and use the theory as tools to answer those questions. Students greatly appreciated that we used the steps involved in running a breeding program as main thread through the course Some fine-tuning is needed with respect to order of subjects and the balance between classroom lectures and applying the theory in practical assignments.

Keywords: animal breeding and genetics; undergraduate students; course development

Introduction

Most undergraduate students in Animal Sciences at Wageningen University will not proceed in a career in an animal breeding related field of work. In fact, many of those undergraduate students are not even interested in knowing more about the field of animal breeding and genetics. Last year we were facing the challenge of updating our undergraduate course in Animal Breeding and Genetics. After having been very successful and appreciated by the students for many years, in the past 2 years the course was evaluated as uninteresting and not very useful. In other words: action was required. First we needed to understand what had caused this change in evaluation. We could identify two potential reasons: 1. The course was re-scheduled from the third and final year of the BSc to the second year. When the course was scheduled in the third year, students had already taken in-depth courses related to other fields of animal science, and they also were more mature. 2. The student population had changed because their education program at high school had changed, and they were thus used to a different type of teaching. Therefore, instead of updating we decided to take on the challenge and completely renew the design and content of the course. Our main aim was to design the course such that the students would take home a realistic impression of what is animal breeding and that it is more than 'doing some complicated things with co-variances and h^2 ². Because the majority of the BSc-students is not interested in animal breeding, those students were our target group and to a lesser extent the students who would like to specialize further in Animal Breeding and Genetics in their MSc. As a side effect, we were hoping that more students will decide to specialize in animal breeding in their MSc. In Wageningen, approximately 95% of the animal science students proceed with an MSc after finishing their BSc, the

large majority of them in animal sciences, of which annually only 5 to 10 students choose to specialize in Animal Breeding and Genetics out of approximately 120.

While designing the course we realized it required a lot more thinking than we anticipated. In this paper, we would like to share the thinking process, present some of our first experiences with teaching in the new setup, indicate where we need to further improve the course, and present some of our wishes for additional features.

Materials and Methods

Student population and position of the course. The Animal Breeding and Genetics (ABG) course is scheduled in the first period of the second year of their BSc study program in Animal Sciences. It is taught during 6 weeks of afternoon classes, followed by 1 week to study and 1 week with exams (i.e. study load of 6 ECTS). It is their first course in English, which makes it slightly more complicated for the students. Our course is compulsory for all undergraduate animal science students, and is the first more in-depth course in their study program. In the first year, they have taken courses related to general animal science, mathematics, statistics, and chemistry. Most students are 19 or 20 years old at the time of the course and they come straight to university after taking the 'VWO': the most advanced level of highschool that gives direct admission to the university. During the past 3 years the number of students taking the course varied between 110 and 140. Each year approximately 15 of those students were MSc students because we also strongly advise our MSc students who took their BSc degree elsewhere to take this course before taking the MSc courses on animal breeding.

Original course content and teaching methods. The original course followed the perspective of a logical way to learn the separate subjects. It started with monogenic model, proceeded to polygenic, variance components, genetic relationships and inbreeding, genetic models, breeding value estimation, genetic response, breeding programs, crossbreeding, and long term consequences of selection. Advantage was that from a scientific point of view there is logic in the order of subjects. Disadvantage was that it took until we discussed breeding programs halfway in the course, before students realized WHY they had to learn all those subjects so far.

In the original course design, we used 4 out of the 5 afternoons per week for actual teaching. The fifth afternoon was for self-study. A typical afternoon consisted of 2x45 minutes of theatre lectures (single teacher), followed by 2x45 minutes of working on assignments in pairs in a computer classroom (3 additional people assisting the teacher). Some of the assignments were open questions, but most consisted of electronic multiple choice questions with direct feed-back. During the last two weeks of the

course the students worked in groups on designing their own breeding program for a species of their choice. Grading was mainly based on a written exam and for 20% based on scores of the multiple choice assignments and the report on the breeding program design. Three of the lectures were given by invited speakers, generally from animal breeding companies, to show what animal breeding is like in practice.

Stepwise approach. Based on experience and on guidelines presented in Butcher et al. (2006) we took the following steps to redesign the course:

- 1. Specify learning outcomes for a BSc graduate continuing with an MSc, but not necessarily in Animal Breeding and Genetics
- 2. Decide on what subjects should be in the course and put them in a logical order
- 3. Decide on teaching methods
- 4. Design lectures and practical assignments
- 5. Design examination strategy
- 6. Test the new set-up in practice
- 7. Use results to adjust and refine
- 8. Write lecture notes
- 9. Fine tuning:
 - a. Have a critical look at the teaching and examination methods and adjust where needed/desired
 - b. Find nice additions to bring Animal Breeding and Genetics theory more alive

Results and Discussion

Renewal process. Our very first step in the renewal process was to think about what main message we would like to get across to students. We were aiming to design the course such that in their future career students would still have a fair idea on what is animal breeding.

Our idea was to present the course content with emphasis on the questions, and use the theory as tools to answer those questions. Examples of those questions are: 'I have a population, what exactly do I want to improve? And what kind of information is required to achieve that? ' or 'how do I know which animals are most likely to produce the best offspring?' or 'how many animals should be selected as parents so that genetic variation is maintained? and 'what are consequences of using fewer animals as parents?'. We hoped that by taking the questions as point of departure the message will land better in the students' memories. So that in their future career they remember.

Because we are both trained in the 'old school' to learn first the theory step by step and then learn what practical applications it has, this question based approach was new for us. It is very easy to stick to old habits, so the important step we had to take in the renewal process was to throw aside all old material and start from scratch

We started off by designing a graphical representation of the steps that need to be taken to design a successful breeding program (see Figure 1). Based on that we designed a list of questions that required answering to take those steps. We took that list as point of departure and designed the course around it. The order of subjects largely depended on the order of steps. We tried to show that setting up a breeding program is not only about making genetic progress, but also about managing genetic variation. Also in large populations. In addition, evaluation of your achievements is essential in running a successful breeding program,



Figure 1. Schematic overview of the steps taken in a breeding program that is used as backbone to the BSc course in Animal Breeding and Genetics.

We decided to incorporate genomics into the course as a tool in a breeding program, and show where it can and will be used: for example, in DNA testing to confirm parentage or carrying a certain genetic disorder, and in breeding value estimation, i.e. genomic selection. As it is not part of running a breeding program, we don't teach how genes, nor QTL, can be detected, but we do explain what kind of markers are available and what are pros and cons of those. Monogenetic inheritance was a special issue. We decided to take that as a separate subject and apply the full circle (Figure 1) to it, for example, how to deal with a monogenetic defect and what are consequences for the population of certain selection decisions.

Teaching method and material. In the process of deciding what subjects should be in the course we created lectures in PowerPoint. Making slides is an ideal way to order subjects and subjects within subjects, and to get a nice flow in the whole course. After finishing what should be in the course, the next step was to decide on teaching methods. We soon realized that it was very hard to decide on incorporating new methods without having experience in teaching the new (order of) subjects. Therefore, we decided to keep the 4 lectures per week as we had in the previous course and try one year whether that is a good teaching method with the new course approach.

We needed to revise the practical assignments because many of the old ones did not fit the content of the course anymore. We decided to continue to use some electronic multiple-choice questions with automatic feedback. Students appreciate these questions because they can also use them to check themselves when they are studying for the exam. In addition, we developed a number of assignments that fitted to the new structure of lectures. In a number of assignments, we used Excel so that students would be encouraged to go beyond the actual question. By changing some input you can very easily try a number of scenarios.

On top of these assignments, we wanted to offer a challenging assignment in which the students would go through the whole breeding program cycle step by step. A similar assignment was also present in the previous version of the course. However, because the course is now taught in year 2 instead of year 3, the students require more clarification of what they are supposed to do exactly. Where the assignment used to allow freedom of choice of a species to develop the breeding program for, we now had all students work (in pairs) on the same animal species and we had a list of predefined questions they needed to answer. They all worked on dairy sheep, but they still had some freedom, for example in defining the breeding goal, or in deciding on the population structure. We allowed them that freedom to make the breeding program their own project, but also to have them experience that not everything is written in stone and they needed to deal with some uncertainties. The breeding program assignment is scheduled in weeks 4 and 5 of the course so that students were applying the theory they learned during the weeks before.

First experiences. We have taught the course in this new form for the first time in September-October 2013. We started each lecture with Figure 1 and indicated where we were in the breeding program cycle, which subject would be discussed that day, and what was its role in (the design of) the breeding program. The aim was to show the students that each subject was taught with a purpose in the larger overall goal: to genetically improve a population. Two of the 105 students were repeating the course and could judge the difference. Both of them agreed that it was easier to understand why they had to learn about the numerous subjects and where it fitted in the general picture. Also other students very much appreciated the use of the schematic overview of steps involved in a breeding program as being the thread through the course. Many students really enjoyed the three guest lectures by people who worked in the field of animal breeding, but outside the university. They appreciated to get an impression of how animal breeding theory is applied in practice. However, not all comments were positive. At Wageningen University each course is evaluated by the students who took the course through an electronic questionnaire, directly following the course (usually once per year). The evaluation of the course provided us some points for further improvement:

- We need to think about reducing the number of lectures.
- We need to refine our breeding program assignment to clarify further what exactly is asked from the students. Although our desire was to let them experience some level of uncertainty, it was not very well received.
- Instead of lectures students preferred more tutorials in which they can work on problems and get some feedback on those problems.

In addition, we need to fine-tune the order of the subjects. As an example, we need to make sure that we explain what is a breeding value before we start using the term. But also we need to decide whether we explain about genetic response before or after we explain about estimating breeding values. This year we did a bit of both and that is not optimal.

Additional plans. Our aim of bringing the field of animal breeding more alive thus far has only partly been achieved. The students appreciated that they knew why they had to learn certain theory and they liked the Excel based exercises, but we think we can do better. We would like to add a game element to the course so that students learn animal breeding by practicing in a competition format. We would like to have a simulation game where pairs of students are in charge of a breeding program and make selection decisions. The simulation program reports the results for each pair of students. The aim is to have the best results across all students. It would make students motivated to really think about what their decisions would imply. Additionally they would experience that even though you would make the best selection decisions, there is a chance factor (e.g. Mendelian sampling, unpredictable correlated responses, but also unexpected environmental influences like a disease outbreak) that would still play a role and results may be not as good as you predicted. Unfortunately, we do not have such simulation game available. It would be nice if we could join forces with other universities to develop something together or collaborate with those that have already such software available, such as the Dairy Cattle Simulation Program (Medrano et al., 2010).

Conclusion

The choice of using the steps involved in running a breeding program as main thread through the course was greatly appreciated by the students. Some fine-tuning is needed with respect to order of subjects. The optimal balance of classroom lectures and applying the theory in practical assignments and/or classroom tutorials still has to be established. Use of a simulation game would make the animal breeding theory come alive for the students.

Literature Cited

Butcher, C., Davies, C., Highton, M. (2006). Designing learning. Routledge, London and New York.

Medrano, J. F., Ahmadi, A., Casella, J. (2010). J. Dairy Sci. 210 :2816-2826.