SCENARIO-BASED APPROACH FOR TEACHING BIOSTATISTICS TO VETERINARY STUDENTS

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We used a scenario-based approach for teaching the tests of hypotheses to veterinary students at The University of Sydney and later administered a questionnaire to a sample of students (n = 24) to obtain information about their perceptions of this approach. Nineteen of the 23 students agreed or strongly agreed that this approach made the subject interesting and easy to follow. Similarly, about 80% of students agreed/strongly agreed that the approach helped them to understand the concepts and gave them an idea of how they might apply biostatistics in their professional lives. Overall, the scenario based approach appeared to be received favourably by the students although further efforts are required to improve students' generic perceptions about the subject.

INTRODUCTION

Biostatistics is considered a difficult subject to teach, particularly to veterinary and medical students who do not see its direct relevance in their professional practice. Various authors use unflattering adjectives to the practice of teaching biostatistics ranging from 'challenging' (Herman, Notzer, Braunstein, & Steinberg, 2007) and 'unrewarding' (Simpson, 1995) to 'discouraging' and 'frustrating' (Campbell, 1990). Numerous reasons are quoted for these unpleasant experiences, such as, 'taught too early in the course' or 'the lack of availability of computing hardware and software' (Lopez, Fabrizio, Plencovich, & Giorgini, 2004), but the major stumbling blocks are the students' perception that biostatistics is irrelevant to them, that they are not going to use it in their professional life, and that they were wasting time studying this subject ("…they all get it, while few of them want it" (Peters, 1990)). This perception stems from applying the same curricula and teaching approaches to veterinary and medical students as used for teaching undergraduates in other degree programs.

In contrast to students' perceptions, the curriculum designers and veterinary and medical teachers believe that biostatistics is absolutely necessary, and in fact increasing in relevance, given the emergence of evidence based medicine (EBM) in the 21st century (Richard, 2002). The medical and veterinary schools want to equip their graduates with the skills in EBM so that they are not only able to understand published literature on clinical trials, observational studies and other medical and veterinary experiments, but also to critically evaluate the literature in order to provide the best informed advice to their clients.

Given the need to teach biostatistics to veterinary and medical students, despite the inherent difficulties in teaching it, new approaches must be considered when teaching students with non-mathematical backgrounds. It has been felt that "…what we teach is actually less important than how we teach" (Christopher, 2002). Facing similar problems as other teachers of biostatistics, we adopted a scenario-based approach to teach biostatistics, particularly the tests of hypothesis, to veterinary students in which we developed four case studies to teach as many tests of hypothesis. Later, to obtain information about students' perceptions of this approach, a questionnaire was administered to a sample of students. In this paper we present our scenario-based approach to teaching biostatistics and the results of student survey about their perceptions of the approach and the biostatistical teaching in general.

METHODS

The case study approach was implemented at the Faculty of Veterinary Science, The University of Sydney for teaching biometry to the second year veterinary students. Biometry, a component of the Genetics and Biometry unit of study, is delivered as two one-hour lectures and one one-hour computing practical per week. The alignment with Genetics is primarily for convenience; both subjects are taught separately, but connections are made where appropriate. The classes for lectures are usually large (around 100 students) but are split into four groups for computing exercises or practicals.

The four case studies prepared to impart skills in tests of hypothesis (listed in Table 1) were delivered in four one-hour lectures using a similar delivery approach (see Box 1 below). Briefly, a scenario is presented in the beginning, usually in the form of a problem and the test of hypothesis is presented in the context of that problem. Students are engaged in the whole process of the conduct of the tests of hypotheses, such as, in specification of the null and alternative hypotheses, testing of assumptions, and interpretation of *p*-values and confidence intervals. Focus is maintained on the original problem over the whole lecture rather than on the conduct of the test of hypothesis, giving an impression as if the students were solving a real-life problem.

To get an idea about students' perceptions of this approach and their overall learning experience, an informal questionnaire was administered to a conveniently selected group of students (essentially the students in a practical session; $n = 24$). The questionnaire had 17 questions in total: the first five were related to the subject itself; the next five to the case study approach used in teaching; and the last seven were designed to get students' responses about the practice of teaching. The students were asked to select one of the five options, viz. strongly disagree, disagree, neutral, agree and strongly agree. Questions and student responses about the case study approach are presented in Table 2 while those about student perceptions about biometry in Table 3. The questions about the practice of teaching are not discussed here in detail.

Table 1. Scenarios used to teach the tests of hypothesis to the second year veterinary students at the Faculty of Veterinary Science, The University of Sydney. Except the dataset used for 1-sample *t*-test, all other datasets were based on real studies but were modified for pedagogical purposes.

S. No.	Topic	Scenario	Dataset	Variable/s	Number of observations
1	1-sample *t*-test	Comparison of beer consumption by veterinary students with the Australian Bureau of Statistics (ABS) national average	Simulated	Beer consumption per week (litres)	25
2	Student's *t*-test (pooled variance)	Comparison of weight gain in piglets managed by different stockmen	A subset of the AP2 dataset (Dohoo, Martin, & Stryhn, 2004; Vigre, Dohoo, Stryhn, & Busch, 2004)	Daily weight gain (g); Stockman	30
3	2-sample *t*-test (unequal variance)	Comparison of the calving to conception interval in cows inseminated by natural and artificial insemination in Reunion Island	A subset of the REU_CC dataset (Dohoo et al., 2004; Dohoo, Tillard, Stryhn, & Faye, 2001)	Calving to conception interval (days); Insemination approach (natural or artificial)	155
4	Paired *t*-test	Comparison of students' scores in two biometry quizzes	Based on the quiz scores of a sample of veterinary students at our faculty	Quiz 1 scores; Quiz 2 scores	34

Box 1. A typical scenario-based approach used for teaching the tests of hypothesis to the second year veterinary students at the Faculty of Veterinary Science, The University of Sydney. This example scenario 'Comparison of the calving to conception interval in cows inseminated by natural and artificial insemination in Reunion Island' was based on the REU_CC dataset (Dohoo et al., 2004; Dohoo et al., 2001) and used to teach the two-sample *t*-test for unequal variance.

Students are asked at the outset to imagine as if they were working as veterinarians with the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) in Reunion Island and that they have been assigned responsibility to investigate the reasons for poor reproductive performance in dairy cattle in the island. Veterinary students are trained to solve disease and production problems and this notion of investigation of reproductive problems fits quite well with what they study in other courses.

Once the context is set, the aim of the study is made more specific; students are informed that their objective is to determine the factors associated with the calving to conception interval (CCI), one of the indicators for reproductive performance. Based on previous lectures in the course, they understand that comparisons can be made between different subgroups to solve such herd problems. For example, for the current problem, they could compare CCI between sub herds managed by different managers, cows with and without postpartum disorders, cows inseminated by different technicians, cows inseminated by natural and artificial insemination techniques and so on. However, they are informed that for the particular case study being discussed in the class, they would only need to compare the CCI between naturally and artificially inseminated cows.

Explanation of study objective is followed by descriptive analyses conducted live in the lecture with the students being asked to interpret the summary statistics and the graphical summaries, particularly the box-and-whisker plots. Given that students already understand the basic steps of hypothesis testing, they are asked to specify the null and the alternate hypotheses, given the study question. It is made sure that they refer to the population of cows while specifying these hypotheses rather than the sample obtained. Hypothesis specification is followed by testing of the assumptions of the two-sample t-test for pooled variance, i.e. the assumption of normality and homoscedasciticity (again done live in the lecture). Students are again involved in the interpretation of the assumptions of the test of hypothesis. In this particular scenario, the assumptions of the test fail and the data have to be logarithmically transformed, after which both the assumptions of normality and homoscedasciticity are satisfied. This also explains to the students how these tests are conducted in the real-life.

The actual hypothesis test is then conducted and the students are asked to interpret the *p*-value and the confidence interval and to make conclusions that are then again related back to the original problem. Thus the actual conduct of test of hypothesis is sandwiched between the real-life problem and its solution. Although both the manual and computer calculations are demonstrated in the class, this activity is not given a major emphasis as the main focus stays on the reproductive problem throughout the lecture. The lecture is finished by presenting some other examples of the use of this test and by asking students to interpret the 2-sample t-test results presented in a journal article.

RESULTS

Twenty-four students participated in the study. The case study approach appeared to be taken favourably by students, given their responses during the lectures and their feedback to the questionnaire. A summary of the students' responses about the scenario-based approach are presented in Table 2. Briefly, nineteen of the 23 students agreed or strongly agreed that the case study approach made the subject interesting and easy to follow. Similarly, about 80% of students agreed/strongly agreed that the approach helped them to understand the concepts and gave them an idea how they might use biometry in their professional lives. Interestingly, 19 of the 24 students also desired the approach to be applied to practical sessions whereas only two believed that the approach made the subject confusing and needed to be discontinued.

Table 2
Student responses to the questionnaire administered to obtain feedback about the case study approach to teaching biometry at the Faculty of Veterinary Science, the University of Sydney.

Questions	**Responses**	**Frequency** (n = 24)	**Relative Frequency (%)**
1. The case study approach to learning biometry made the subject interesting and easy to follow.			
	Strongly disagree	0	0.0
	Disagree	1	4.4
	Neutral	3	13.0
	Agree	16	69.6
	Strongly agree	3	13.0
	Frequency Missing = 1		
2. The case study approach helped me understand the concepts.			
	Strongly disagree	0	0.0
	Disagree	3	12.5
	Neutral	1	4.2
	Agree	14	58.3
	Strongly agree	6	25.0
3. Case studies gave me an idea of how I might use biometry in my professional life.			
	Strongly disagree	0	0.0
	Disagree	1	4.2
	Neutral	4	16.7
	Agree	15	62.5
	Strongly agree	4	16.7
4. The case study approach should also be used for the practicals.			
	Strongly disagree	0	0.0
	Disagree	2	8.3
	Neutral	3	12.5
	Agree	14	58.3
	Strongly agree	5	20.8
5. The Case study approach to learning biometry made the subject confusing and should be discontinued.			
	Strongly disagree	4	17.4
	Disagree	15	65.2
	Neutral	2	8.7
	Agree	2	8.7
	Strongly agree	0	0.0
	Frequency Missing = 1		

However, the case study approach did not appear to influence students' general perceptions about the subject as only less than half of the students agreed/strongly agreed that biometry helped them develop research and inquiry skills and that the subject is relevant to their degree (Table 3). As a subject, biometry was perceived to be boring by many ("As interesting as biometry could be?"; "Whilst he tried his best, it was not a subject I enjoyed") although others seemed to enjoy it which was rewarding ("I understand it is a difficult subject to teach and one

many students don't enjoy. However, [the first author] made it a fairly enjoyable experience and provided good learning environment"; "I thoroughly enjoyed the course although it tends to become more tedious towards the end"). One student sums up students' perceptions about the relevance of biometry, "as a clinician, not really, as [a] researcher, absolutely" which was partly disappointing. Nevertheless, about 68% of students were satisfied with the teaching of biometry which was gratifying.

Table 3
Student responses to questions about their perceptions of biometry in the questionnaire administered at the Faculty of Veterinary Science, the University of Sydney.

Questions	**Responses**	**Frequency** (n = 24)	**Relative Frequency (%)**
1. Biometry helped me develop research and inquiry skills.			
	Strongly disagree	0	0.0
	Disagree	5	20.8
	Neutral	9	37.5
	Agree	8	33.3
	Strongly agree	2	8.3
2. I can see the relevance of biometry to my degree.			
	Strongly disagree	1	4.2
	Disagree	6	25.0
	Neutral	6	25.0
	Agree	10	41.7
	Strongly agree	1	4.2
3. Biometry is boring and useless.			
	Strongly disagree	1	4.2
	Disagree	8	33.3
	Neutral	11	45.8
	Agree	4	16.7
	Strongly agree	0	0.0
4. The lecturer stimulated my interest in biometry.			
	Strongly disagree	0	0.0
	Disagree	4	18.2
	Neutral	8	36.4
	Agree	6	27.3
	Strongly agree	4	18.2
	Frequency Missing = 2		
5. Overall I am satisfied with the teaching of biometry			
	Strongly disagree	0	0.0
	Disagree	1	4.6
	Neutral	6	27.3
	Agree	10	45.5
	Strongly agree	5	22.7
	Frequency Missing = 2		

DISCUSSION

Teaching of biostatistics to veterinary and medical students has long been considered difficult and challenging, given the primary aim of students is on acquiring clinical rather than mathematical skills. However, a part of the problem also lies in the approach to teaching biostatistics in which a greater attention is usually paid to mathematical calculations instead of the concepts useful for veterinary and medical students. Further, the specific requirements of veterinary and medical undergraduates are ignored, which of course, are different than those in other graduate programs ("the courses have become much too long, too detailed, and irrelevant to the needs of the majority" (Appleton, 1990)).

To overcome these problems, some authors advocate the need to emphasise critical appraisal skills (Astin, Jenkins, & Moore, 2002; Evans, 1990) while others promote the use of case studies (Nolan, 2002). However, there is only limited information on their application to the teaching of biostatistics to veterinary students. The results of current study suggest that the biostatistical skills can be more effectively imparted to veterinary undergraduates using scenario-based approaches. Both the experience of the lecturers in the classroom as well as students' feedback in this preliminary survey indicate that the approach was successful, although a lot needs to be done to improve generic perceptions of students about biostatistics.

These four scenarios were delivered in a consciously created relaxed learning environment using humour amalgamated with examples from interesting research articles demonstrating application of biometry principles. Almost every lecture had examples from research articles particularly published by postgraduate students and academics in the faculty. For example, many fundamental concepts such as the central limit theorem were discussed in the context of the study conducted to understand the demographics and husbandry of pet cats living in Sydney, Australia (Toribio et al., 2008). It is believed that this general approach to teaching would have had an impact on student responses; therefore, the 'pure' effect of the case study approach on student perceptions was difficult to measure.

Similarly, the teaching style could also have biased the results. In the same questionnaire, we asked students about their views on the practice of teaching. The results of students' responses to these questions are not relevant to this paper, but none of the students disagreed/strongly disagreed to the statements that the presentations were clear and understandable; that the lectures were properly structured and easy to follow; and that the lecturer was enthusiastic about biometry. In fact, all the respondents to the last question strongly agreed to the statement! This response could in part be due to the case-study approach used in the lectures which created an environment of student focussed learning, but on the other hand, the teaching method used by the lecturer could also have biased students' responses to the questions about the case study approach. Further studies are required to separate the effects of teaching from the effects of scenario-based approach.

A major drawback of this study was a smaller sample size and a convenient selection of students from a practical group. However, students in practical groups were allocated using simple random sampling, and therefore, the sample obtained for this study can be considered to be fairly random, except the presence of some group effect. The small sample size is justified given that this was just a preliminary investigation and that only descriptive analyses of data were conducted. However, further detailed studies with a larger sample size are required if any analytical approaches are to be used to understand the effect of the scenario-based approach on students perceptions.

The less than desired influence of the approach on generic perceptions about the subject was disappointing, indicating that it is a challenge to change the long held views of students. However, given their feedback about the case study approach, it appears that other aspects of teaching such as the practicals/tutorials need to evolve inline with the approach used for lecturing. Further work is probably needed to develop tutorials on explaining application of biostatistics in EBM and in critical evaluation of results presented in journal articles. In general, it is believed that the scenario-based approach was a good beginning and further efforts are required to improve student perceptions and interest in the subject.

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