THE STUDENT PROJECT: THE IMPORTANCE OF USING STATISTICS IN BEING AN AGRICULTURAL SCIENTIST

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The use of real world projects in introductory statistics courses has become common practice, and the advantages of active student participation in the learning process have been well documented. Involving students in small groups also addresses the problem of large class size and outcomes specified by the South African Qualifications Authority. However, finding a research topic that would generate common interest, and incorporates project management and experimentation, when students come from a variety of subject fields is a challenge. In the South African context diverse backgrounds and accommodation on/off campus also need to be considered. Although learning through play is not usually associated with teaching at tertiary level, feedback from third year Agricultural Science students has shown that project topics with a fun element not only enhance successful learning, but contribute to positive attitudes of students towards statistics.

INTRODUCTION

Statistics educators at tertiary level have increasingly recognized that students learn better from working with real data and by being actively involved in the learning process (Mackisack, 1994; Smith, 1998). Similarly, the role of collaborative learning has been emphasized by educators (Garfield, 1993; Springer et al., 1999). In South Africa the opportunity for putting into practice what they learn and the ability to interact effectively in a learning group are specified in the national qualifications framework as descriptors of academic programs at undergraduate level (SAQA, 2004). Similar descriptors are in use in other countries (Sears & Wood, 2005).

One of the developments towards pedagogy including both active learning and group work has been the student projects. A variety of examples of projects, suggestions for structure and implementation, and ways to best assess group projects are readily available in journals and on the web (see, for example, James et al., 2002).

Most of the projects described in literature are aimed at introductory level statistics, or statistics majors. In the first instance the projects are often class-based, not at a challenging mathematical level and the data are obtained from surveys or observation. Student reports are often verbal, rather than written, and individual, rather than collaborative. In the latter instance the projects suppose a certain degree of proficiency in probability and mathematical statistics (see, for example, Fillebrown, 1994; Scott, 1976).

Few projects seem to concentrate on statistical reasoning and skills that will be needed by future researchers in the biological sciences who are not necessarily mathematically inclined, but of whom it will be expected to design research projects, execute them, analyze and interpret the data and report their findings (Anderson-Cook, 1998). Some examples of lab or field based student research projects are discussed by Sears and Wood (2005). These examples make it clear that students in the biosciences need something more than what is taught at introductory level, and something less than what is taught at major level.

At the University of South Africa Agricultural Science is offered as a four year degree that has as an objective the development and training of future Agricultural scientists. This paper will describe how the student project is implemented in the Biometry course to help develop the skills of third year students in the planning, execution and analysis of scientifically sound projects involving experimentation and team work. Simultaneously, it is hoped that their understanding of and appreciation for the role of statistics in science will improve by being exposed to real data and the ‘fun’ side of statistics.

THE PROJECT FRAMEWORK

The assignment comprises a single out-of-class project that has to be planned, executed and completed over a period of two months. Due to large class size (typically 75–85), and in order to facilitate cooperative learning students work in groups of three or four. They are allowed to form their own teams, but a student is assigned to a group if he/she has not joined a team by the end of

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the first week. The team members do not necessarily know each other well, and/or may not have the same major subjects. Each team also appoints a group-leader and chooses a name. Some of the more respectable names include 'Fantastic Four', 'Airforce One', and 'Stat rats'.

Different experimental designs, concepts, statistical methods, statistical modeling and inference, and use of Excel are all covered in class well in advance of project deadlines.

At the start of the project one tutorial period is set aside to assist the students in getting started on planning the project and designing the experiment. During this work session they have to pay particular attention to identification of risk factors, interference factors, determine costs, identify individual tasks and assign dates of completion to each task. By the end of the following week each group has to submit a field plan of the experiment in which the type of design, number of repetitions, and levels and order of treatments are clearly indicated.

After conclusion of the experiment the data are analyzed using Excel. The nature of the data collected should be such that both a regression and classification model could be fitted, thus allowing for a goodness of fit test of the regression model. Visual presentations of the data and residual analysis are also expected.

A single group report is submitted. Although the report has to correspond to the typical format of a scientific paper, they are allowed to include photographs of themselves, fun pictures or imagined background stories. A final report, in which actual completion dates, costs and any changes to the original field plan are recorded, is also submitted at this stage.

PROJECT TOPICS

Due to the diverse nature of the student group in terms of background, financial means, major subjects, and whether they live on/off campus it is essential that the project topic is generic enough to transcend these differences, and not require too much time, resources or specialized equipment or facilities. In addition, the project topic should be interesting, have no obvious right answers, and also provide some fun during the experimentation stage.

The whole class is given the same topic, but the specifics will differ from group to group. Topics are rotated from year to year, and currently include the following:

- Determine the effect of change in size/mass on the distance that a paper airplane can fly (Paper is any material that can be put together with glue, staples, pins, string or paper clips).
- Determine the effect of intensity/duration in exercise on heart rate. Also determine whether there are differences between males and females.
- Determine the effect of quantity/concentration of a legal/over-the-counter stimulant (e.g. coffee, energy drink) on heart rate. Students have to stay below maximum levels suggested by the pharmacist on campus, and washing-out periods between treatments are compulsory.

ASSESSMENT OF THE PROJECT

At the completion of the project each student has to evaluate the contribution of each group member, including his/her own. This is done by dividing a mark of 10 between all three of four members. The group mark, based on the written report, is then adjusted accordingly for each individual.

As many students are second language students, and all reports are prepared with MS Word, grammatical or typographical errors are ignored. The project is worth 10% of the class mark, on which students earn admission to the final examination.

A rubric summarizing the important characteristics that the project should include is used by the course instructor for assessing the written report. Marks are allocated for creativity and appearance (2), project and experimental design (4), data analysis and results (7), discussion and conclusions (5). Two additional marks may be allocated to students who according to the peer evaluation contributed more than their fair share.

During the report-back session certificates are awarded for the best project (Dream team award) and the best design (Einstein award). In order to enhance the fun element certificates may also be given for arbitrary 'achievements' such as being the team that had the most fun or were the most audacious, being the student who achieved the best throw, or for the best or most interesting photo.

STUDENT RESPONSES

After completion of the project the students have the option to rate the project by awarding a score of 1–5 (horrible–very cool), and/or comment on the project. In 2009 eight students out of 26 (31%) and 15 (58%) gave the project a score of 3 and 4 respectively. Comments included the following:

- Very interesting–learnt a lot.
- There are factors that could have influenced the accuracy of the results, difficult to get a significant result.
- We were able to put our knowledge of biometry into practice, conducting a basic experiment from start to finish, which makes it a nice change from just working through questions and examples.
- I would prefer a topic that concerns my field of study, e.g. in my case fertilization of vines.
- It tests insight and combines everything learnt so far including the use of excel.
- Everyone worked together well.
- It helped me to understand the work better and it was fun.
- It was unscientific experiment and the information obtained was not useful, even though we were able to learn from doing the statistical analysis.

Most comments were positive, although some students did feel the need for project topics more relevant to their subject fields. They did, however, accept the explanation that the emphasis of the project was on method, and that incorrect method, rather than an inappropriate topic, would result in a study being regarded as scientific, or not.

Anonymous student feedback conducted by the Centre for Teaching and Learning at Stellenbosch University in 2001 when the project was first introduced showed that students scored the meaningfulness of tutorials and group activities of the third year Biometry course on average at 3.19 and relevancy at 2.45 on a scale of 1–5. In 2008 these scores increased to 4.22 and 3.51 respectively.

The average pass rate for the third year class has remained stable from 2001 to 2009 at 92.5%. In comparison the pass rate for the second year class which does not do a student project, decreased from 89.8% to 74% over the same period. As there are also other factors that contribute to the differences between these two classes, the extent to which the student project may contribute to the increase in performance remains an open question.

DISCUSSION

Design of the experiment

Although some groups get it right from the start and others re-design their experiments along the way, it is clear that there are still students who do not understand the concept of independence of observations (25%). They would, for example, throw the same paper airplane over and over, note that it becomes damaged but put no measures in place to compensate for the damage. Randomization also seems to be a problem for about the same number of students. For instance, each group member would be taken as a block, but the different levels of the treatment would be carried out in exactly the same random order in each block. The concept of variation seems to be well understood (as one would expect from students in the biological sciences) and obvious interference factors recognized.

Analysis of the data

In general data analyses are well done. There are the exceptional cases when a regression model is not fitted, or fitted to the group means instead of to the raw data. Sometimes residual plots are included in the report, but no visual presentation of the observations.

Interpretation of the results

About 25% of students do not understand hypothesis testing at all. Hypotheses are phrased incorrectly (e.g., there is a relationship between X and Y), and/or the null hypothesis is rejected when the P value is large. Students also state that they accept the null hypothesis, or that it has been proved that the null hypothesis is true. Similar mistakes are reported by Zeleke et al. (2006). This clearly illustrates that even when students understand some of the basic principles, are able to choose the correct method of analysis, and are proficient in their use of computer programs, probability and using probability distributions to make inferences about the underlying population still remains a mystery to many a student.

Discussion of the experiment and results

There is a general realization that real data may be very different from textbook data and small differences between treatments may go unnoticed if not enough control over variation has been built into the design, or if the experiment is too small. However, there is some confusion that non-significance of results means that the research has been unsuccessful. The importance of thorough design is well understood and students are able to make good suggestions for improving their current designs.

CONCLUSION

Although concepts of design and analysis of experiments may be included in courses intended for students who are not statistics majors, students still need opportunities to practice the skills required to design and conduct scientific experiments, to analyze and interpret real data, and to communicate their results. The student project provides such an opportunity. When the demographics of the class are such that it is difficult to find topics related to their major subjects that do not require specialized equipment or lab-facilities, a generic topic with a fun element may spark common interest.

Student responses have shown that such assignments make a valuable contribution towards increasing their understanding of statistical concepts and applying them in practice. Simultaneously student attitudes towards statistics may be improved. Better understanding and better attitudes would also impact positively on the learning success of students.

In conclusion it is hoped that exposure of the student to the principals of project management, experimentation and team work will lead to the student electing to become the successful Agricultural scientist of the future.

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