Critical Analysis of Statistical Methods
used in Research Papers

Abstract

Statistical modules within engineering postgraduate programmes can be particularly demanding to design and deliver in an effective manner, as the prior knowledge of students entering the programme can be vastly disparate. A good example of this is the “Statistical Analysis for Engineers” module taught in Dublin Institute of Technology to a combination of full-time M.Eng. students, part-time M.Eng. students and full-time Ph.D. students. Within this group, there is also a clear divide between mature students returning to education after a number of years in the workplace and students who have just completed their undergraduate degree. Due to the wide range of experience and abilities within the group in question, it is necessary that the module be entirely self-contained; however the time allocated to the module is limited. To overcome this and other challenges it was decided to introduce a critical analysis component, part of which would consist of students working in pairs to review an assigned research paper. Students were required to give a short presentation including an overview of the paper, a critical analysis of the statistical methods used and an evaluation of the paper as a whole. Students were peer-assessed and required to complete an online reflective survey. Full details of the approach involved and the inherent benefits for students will be discussed in this paper.

1. Introduction

The work presented here refers to a module entitled “Statistical Analysis for Engineers” on a M.Eng in Advanced Engineering. In the first year of the course there were 28 students who were a mixture of full time, part time and PhD students. These students have entered from a wide variety of Engineering programmes and a significant minority of them had not studied much statistics before at any level. In addition to this the majority of the students had done a comprehensive module in Statistics in their undergraduate course. In teaching this module I was faced with the twin challenges of producing a module that is self contained, i.e doesn’t assume much prior knowledge of statistics, yet sufficiently challenging for the students who had studied statistics at undergraduate level. In addition to this I have aimed to introduce an element of ‘critical thinking’ into the course.

1.1 Critical Thinking

“Critical Thinking is a way of thinking that does not accept any assumption without questioning its validity and correctness” [1]

The ability to think critically is an extremely important skill for our students, both as citizens in everyday life and as engineers working to solve complex problems. In particular we want to make our students approach technical papers with a critical
outlook on the statistical techniques used. The students had to work their way through a lot of technical jargon, from areas as diverse as biomedical engineering and structural engineering. The challenge for them is not to be overwhelmed by this and still be able to think critically about the statistical analysis involved.

1.2 Overview

Students worked in pairs to review an assigned research paper over a series of weeks. They then gave a ten-minute presentation which included an overview of the paper, a critical analysis of the statistical methods used, an evaluation of the paper as a whole and one-page summary of the paper. They were also required to complete an online reflective survey. This assignment counted for 20% of the module overall. It was hoped that, by listening to the presentations, the class as a whole would be exposed to a variety of different statistical tests.

Each pair was assigned a published paper with a significant statistical analysis component. The papers were deliberately drawn from areas outside of those that the students would normally study. Some examples of the types of papers assigned are:

- Bio-informatics (HIV, Obesity)
- Civil Engineering (Extreme bridge traffic load effects)
- Medical Engineering (Robotic surgery, Clinical trials for stents)
- Manufacturing Engineering (Process design)

2. Rationale

It was hoped that this project would, amongst other things, enable students to think critically about what they were reading. In addition to this, we wished to demonstrate the use of statistics in many real life contexts, enable students to read technical papers where they may not be familiar with all the technical terms and further develop their presentation skills.

3. Results

The students were asked to fill out an anonymous online survey, and we received 15 responses from the 28 students. One of the principal aims of this project was to expose the students to as many different statistical tests as possible. It was not expected that students would have a full understanding of these tests but rather have a sense that there exist more tests than it is possible to cover in a short module. The majority of the students (Figs 1, 2 & 3) agreed that they learned a lot about other statistical methods from both their own presentations and from watching other presentations.
The other main aim of this project was to encourage critical thinking among our students and give them the ability to work their way through a lot of technical language. According to the survey results, the majority of students feel that they would now be much more critical about what they read in a research paper, as shown in Fig 4.

For each student, the difference between their exam mark and their presentation mark was calculated, and the results are shown in Figure 5. It is clear from this that students did significantly better in their exam than in their presentation. This would seem to indicate the need for more projects of this type in Statistical Analysis courses.

This exercise helped students to see statistics in context; one student commented that he “realized from each of the reports some very complicated statistical methods were used, especially within the medical journals”. It also encouraged them to approach academic papers with a more critical outlook; another student felt that he had “learned to view statistical data from a more critical point of view as a result of both the presentation and the course as a whole.”

4. Conclusions and Future Work

Overall this project was popular with students, and the majority of them felt that they learned a lot about statistical methods, both from doing the presentation and from watching other presentations (cf. Fig 1 and Fig 2 in Section 3). However, despite this, it should be noted that there were some complaints about the standard of some of the presentations, with students observing “(S)ome of the presentations did get a little boring” or “(V)ery hard to take anything from some of the presentations.”

Also, whilst the results of this work are generally positive, we have yet to obtain conclusive evidence that this technique improved the critical thinking ability of our students. Measuring such an attribute is particularly challenging, even more so in the space of a period as short as a semester. However, we feel that it is an avenue worth pursuing and therefore, we are currently investigating the use of a number of different concept tests for this purpose, such as Watson-Glaser Critical Thinking Appraisal Test [2,3] and the California Critical Thinking Disposition Inventory [4]. In addition, several focus groups with this cohort of students will be conducted in order to deepen our understanding of the potential benefits of this approach.

The author is also in the process of setting up a database of research papers for use in exercises such as this and would be interested in hearing from other academics who are interested in contributing to such a database.

References