# ENHANCING THE LINK BETWEEN STATISTICS AND MINERAL PROCESSING THROUGH PROJECT BASED LEARNING

Jeeva Periasamy
University of Johannesburg, South Africa
Jeeva2402@hotmail.com

*This paper is a culmination of the study carried out after using project work as an intervention to enhance the learning of statistics as a service subject. It discusses how a project encompassing real-world problems directly relevant to the learners chosen career- path help in motivating and sustaining the students' quest for learning statistics. The sample group comprised of learners studying towards the Diploma in Extraction Metallurgy and the project work was centred on the main-stream course Mineral Processing. This project was based on actual experiments conducted by learners in their Mineral Processing course so that learners could see the relevance of applied statistics to main-stream courses. The learners' performance was tracked throughout this study.*

## INTRODUCTION

The learning of statistics as a service course presents many challenges to learners. They experience difficulty in seeing the relationship between statistics and other main stream courses. Learners constantly question the relevance of statistics to their chosen career path. By merely assigning problems and exercises from various textbooks relating to the learners' field(s) of study, learners are not convinced of the application of statistics to their specialised fields.

Lecturers of service courses are also faced with the challenge of offering them in a manner which encompasses relevance to the learners applied field of study. Mvududu (2003) and other researchers moot that by applying statistics to real-world situations much anxiety in the statistics classroom can be reduced. Several studies (see, for example, Giraud, 1997; Love, 1998; Chance, 1997; Magel, 1998) have shown the shift from traditional assessment and teaching techniques to more innovative ones. Although this study adds to the existing body of knowledge in project-driven assessment, it uniquely focuses on learners establishing a link between statistics and their main-stream Mineral Processing course, all part of the engineering diploma in Extraction Metallurgy.

The intervention of project-based learning was investigated with respect to the performance of learners in sections such as hypothesis testing, ANOVA and chi-squared tests. Although the projects were completed individually, the classroom environment encompassed cooperative learning. Cooperative learning as summed up by Giraud (1997) involves learners working together in small groups to maximise their own and each others learning. The paper describes an intervention through applying statistics to real-world situations to help stabilise or enhance the performance amongst statistics learners and to establish a link between the main-stream courses and statistics. As Mvududu (2003) and other researchers purport that making statistics relevant to the learners "real world" will contribute in encouraging learners to use their knowledge outside the classroom.

## DESCRIPTION OF THE SAMPLE AND THE COURSE

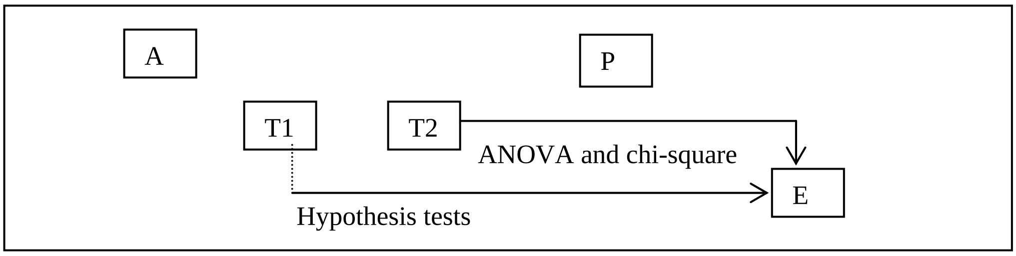
The study was conducted at the Doornfontein Campus of the University of Johannesburg. The university is a comprehensive university with a multi-campus setup offering both degree and diploma programs. The sample group comprised of 23 learners who were registered for the process statistics II course which is in semester III of the National Diploma in Extraction Metallurgy. 96% of learners were from the previously disadvantaged group. The diploma consists of 4 semester's on-campus tuition and 1 semester of experiential training with a suitable mining company.

Learners already had 6 months exposure to basic applied statistics in semester II of their program. This first course in statistics was the usual quantitative methods course and included topics from descriptive statistics, probability, interval estimation, hypothesis testing and linear regression. The lectures were presented in the usual traditional style with the lecturer being the "source of information" (Love 1998). The assessment comprised of 2 main tests and a final exam.

The process statistics II course is made up of hypothesis tests, ANOVA, linear regression and correlation, time-series analysis, multiple regression, goodness-of-fit tests as well as tests for independence and decision theory. The lectures were scheduled on 2 consecutive days and the duration of each lecture was 2 hours. Typically the formal lecturing takes place when new topics are introduced and concomitant new methods are discussed. Most of the class time is utilised on learners actively solving and discussing problems and exercises. The lecturer's role is the "facilitator of learning." Studies such as Love (1998) and Magel (1998) attest to this role of the instructor. The lecturer constantly encourages cooperative learning and learners are motivated to solve challenging problems in small groups.

## RESEARCH METHODOLOGY

To evaluate the effectiveness of project-based learning, learner's performance was tracked throughout the semester. Learner progress is best fostered when assessment entails a linked series of activities undertaken over time (Nair and Pillay, 2004). The assessment comprised of an assignment, a project, 2 tests and a final examination. The research design follows.




A refers to the assignment. This was the first assessment given to learners and was followed by T1 (test 1), T2 (test 2), P (project) and an examination (E). The term mark was the weighted average of A, T1, T2 and P. The final mark comprised of the sum of 50% of the term mark and 50% of the examination paper.

## RESEARCH PROCESS

In the assignment, learners were assigned the task of selecting various sampling methods and to explain them with understanding. They had to support their explanations with examples from the engineering field and more specifically Extraction Metallurgy. Marks were awarded for the correct explanations but a higher weight was allocated to the use of relevant and appropriate examples. Quantifying the percentage of learners who attained performance levels of benchmark value and above (benchmark value is regarded as 50%, which is the same as the pass mark in most subjects) gives 78%. On completion of the assignment, 90% of learners indicated that they would prefer to see statistics applied to practical engineering scenarios. Clearly, this needed to be addressed.

The first 3 weeks of the semester was devoted to a revision of the statistics I syllabus. Emphasis was placed on the understanding of statistics and the ability to reason correctly about statistical information. T1 was based on hypothesis tests and resulted in 43% obtaining above benchmark values. Sections in T2 included chi-square and ANOVA. This test resulted in 61% obtaining above benchmark values.

To make statistics meaningful and purposeful, an intervention in the form of project work was implemented. As summed up by Smith (1998), projects equip learners to ask questions, define problems, formulate hypotheses, collect data, summarise and analyse data and communicate findings. I asked learners to identify other main-stream courses that could lend itself to the application of hypothesis tests, ANOVA and chi-square tests. There was an overwhelming response from learners that the course Mineral Processing was the most appropriate one. Learners had completed the following experiments in their Mineral Processing III course: flotation – recovery by size fraction, flotation – comparison of wet and dry grinding, magnetic separation, gravity concentration using a shaking table and gravity concentration using a spiral. They had worked together in small groups to complete the required 4 out of the 5 experiments. Learners were asked to indicate the statistical techniques that they had used thus far in the experiments. Sampling techniques, measures of central location and dispersion as well as presentation of data was cited by all. Upon examining a few of the completed write-ups on these experiments, it was evident that learners could use hypothesis tests, ANOVA and chi-square tests in validating some of their conclusions in their experiments. The project comprised of open-ended problems: learners were asked to construct 4 sets of questions covering the sections of hypothesis tests, ANOVA and chi-square tests. Learners could base these questions on at least 3 of their experiments. Solutions had to be worked out at the 0.05 level of significance. Marks were awarded for questions being relevant to the experiments, clearly formatted questions, correct solutions and correct interpretation of results. Furthermore, learners were supplied with examples from relevant engineering texts encompassing the above mentioned sub-sections of statistics. The result of the project was that 87% of learners obtained above bench mark values.

## DISCUSSION

By giving learners open-ended problems, the focus will be on how the learners approach the problems and whether they can concentrate on the critical aspects of the problem (see, for example, Chance, 2002). This also helps learners to think beyond the textbook. Open-ended problems lead to more creativity. In the past, I have noticed that learners do not ask many questions. This project not only got learners talking but also had them in and out of my office. The learners had to make decisions on what analysis to perform which is challenging compared to the usual textbook problems which narrowly focuses on exercises based only on the subsection concerned. The most significant feat was the level of interest displayed by the learners in this project. Chance (1997) identified the monitoring of interest levels as one of the goals for using alternative assessment methods.

Since only 16 out of the 23 learners handed back their test 1, I did not use hypothesis tests as part of the analysis. My analysis was based on ANOVA and chi-square tests. I examined the performance of learners in test 2 with respect to ANOVA and chi-square (this was prior to the intervention of the project) and then compared these results with the respective sections in the exams. In analysing the marks of ANOVA, 7 of the 23 learners maintained their marks and it is pleasing to report that the marks that were maintained were all 100%. Even though the Wilcoxon signed rank test ($p = 0.6322$) revealed that the project did not have a significant influence on the before (test 2) and after (exam) results in ANOVA, 91% obtained above benchmark values in test 2 whilst 100% attained above benchmark values in the examination. The median mark of 100% in both cases was also maintained. In the analysis of the marks of chi-square, the Wilcoxon signed rank test ($p = 0.0008$) revealed that the project had a significant effect on the exam results. In test 2, only 30% obtained above benchmark values in chi-square whilst in the exams 78% obtained above benchmark values.

The true test of the worthiness of the project lies in the reactions from learners. An overwhelming 96% of learners indicated that the project helped them to see the relevance of statistics to their chosen career. Even though 22% stated that in general they do not enjoy project work, only 5% indicated that they did not enjoy this project in statistics. 76% preferred projects with open-ended questions. All learners claimed that they experienced a positive change in attitude towards this statistics course. Some comments include: “the challenge is good;” “for once we did not have to think in the box;” “required a lot of thinking and the hardest part was deciding what to use for your test.” Earlier on in the course students were asked to comment on the cooperative learning environment as well as the lecturing style. Some comments were: “I’ve never enjoyed stats before but with this lecturing system, I’m very much satisfied with it;” “there was more understanding and practicality in this course;” “the lecturing style is the best by far, the students are part of the class;” “the content is not as straightforward as most people thought- it is challenging and fun;” “process stats II is more applied;” “very good content, the assessment is appropriate and also gives the right direction which should be taken in solving analytical problems.”

## CONCLUSION

It would be naïve to claim that the project was solely responsible for the enhancement of overall performance in statistics. The cumulative effect of project work set against the background of cooperative learning had most definitely aroused the inquisitiveness and interest of the learners. My observation was that learners had a sense of ownership and pride in the project work undertaken as they were using data which was collected from their experiments carried out in Mineral Processing. Once learners perceived the usefulness of statistics to their future career, the learning process became purposeful. Consequently, their attitude towards studying statistics improved. The collective outcome of the above not only led to better performance in a challenging exam but to deeper levels of understanding. Future research would be to monitor the sample and to see how many of the learners use the statistical techniques that they have mastered in this course outside the statistics classroom.

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