

Projects and Practical Work in an External Examination

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1. Introduction

In New Zealand the external examination taken by the majority of students in the final year of secondary school is the University Bursaries Examination. As the name implies, this influences entry to, and financial support for, tertiary education.

Since this examination was introduced in 1966 two mathematics papers have been offered. For twenty years this offering consisted of a paper in Pure Mathematics and one in Applied Mathematics, which included Statistics. Initially the majority of students took either the Pure Mathematics paper only or both papers. Towards the end of the period, however, a very significant number of students were taking the Applied Mathematics paper only without the backing of Pure Mathematics.

This situation, together with a changing perspective on the relationship between mathematics and its applications, led in 1986 to a complete revision of the mathematics prescriptions for the examination. After considerable discussion with teachers, the Universities Entrance Board, the governing body of the examinations, introduced two new papers: Mathematics with Calculus and Mathematics with Statistics. This arrangement of the material, it was felt, would cater more successfully for the needs of students entering different disciplines in tertiary institutions. Both papers were to be applications oriented which better reflected the important relationship between theory and applications in mathematics and statistics.

Along with this change it was decided to include, in the Mathematics with Statistics paper, a 20%, internally assessed, practical component or project. This decision reflected the philosophy of the often quoted section of the Cockcroft Report (1982) that mathematics teaching at all levels should include opportunities for appropriate practical work, problem solving, the application of mathematics to everyday situations and investigational work. The statement, it was felt, applied even more to statistics than to mathematics.

This was an important change for teachers introducing both compulsory "project" work and internal assessment. Consequently, the Mathematics Steering Committee of the Board decided on a programme to monitor the introduction of the new component and provide feedback to teachers.

At the end of the first year of the new prescription, a comprehensive questionnaire was completed by all teachers and all students involved in the examination, and schools were asked to supply three examples of project work taken from the top, the middle, and the bottom of their internally assessed mark distribution.

For the next two years, twenty schools were selected at random and asked to supply three examples of project work for moderation, and the effects of the scaling procedures used to combine the examination and internally assessed marks were studied.

It had been intended to survey teachers and students again in the fourth year of operation but a restructuring of educational administration in New Zealand, in which the Universities Entrance Board ceased to exist, prevented this. Instead, opportunities were taken to discuss the project component with teachers at conferences and Mathematics Teachers Associations' meetings.

2. The nature of projects and practical work

Initially, one of the major concerns of both teachers and students was to find suitable topics for projects or practical work. However, it seems that this was more of an imagined problem than a real one. Certainly the range of project topics reported even at the end of the first year was very impressive. A categorised list of some 200 topics from the first year was made and circulated to schools. The topics ranged from fairly predictable correlation and survey studies to imaginative topics such as a statistical analysis of a Beethoven sonata.

At least as impressive as the imagination used in choosing topics was the enthusiasm and skill with which the majority of students tackled this section of their work. I had been Chief Examiner for University Bursaries Pure Mathematics some years earlier and was immediately struck by the contrast between the routine, skills-based work which students produce in conventional examinations and their approach to project work. I had expected really good work from the best students, although I was surprised by the sophistication, depth and presentation of some projects. However, I was even more impressed with the character of the work of some of the lower achievers. My experience of marking the examination work of the lower quartile of candidates in conventional examinations was extremely depressing. I felt that the majority of these candidates gained very little, if anything, from their year's work. In contrast, many of the projects from lower ability students indicated a significant level of involvement and learning. The students had usually chosen their own topic, with help from the teacher, and were tackling questions to which they wanted to know the answer.

For example, one particular Maori girl had conducted a survey of attitudes of Maori people to a local Maori radio station. She had prepared a questionnaire, chosen a (more or less) random sample, analysed and presented her results carefully and drawn conclusions concerning the amount and kind of music played, the use of Maori language etc. The report was sent to the radio station who interviewed the girl on air about her work. I am not suggesting that the project was brilliant statistically, far from it. Every

aspect from questionnaire design to the presentation of results could have been better. However, as an educational experience for the student and as a piece of work in its own right it contrasted markedly with her written examination performance for which she had a raw mark of less than 10%.

3. Moderation and scaling procedures

One of the understandable concerns of teachers with the introduction of an internally assessed component was that the assessment should be consistent between schools and. Perhaps surprisingly, this was more of a concern for teachers than for the examining body who were, it seemed, happy to trust teachers to take responsibility for this 20% component. However, a moderation and scaling procedure was devised which, although not without its difficulties and critics, seems to work reasonably well.

The moderation process involved selecting 20 schools at random from the 300 or so schools entering candidates. At the end of the year these schools were asked to send in three samples of project work for moderation. The intention was not to change the marks awarded by the schools for these projects but:

- (i) to provide an incentive for teachers to give the project section of the prescription the attention intended;
- (ii) to provide feedback to schools on how their projects and marking compared with other schools in the sample;
- (iii) to provide information to the examining body for its monitoring programme.

Discussions with teachers indicate that the procedure relieves most of their concerns about other teachers abusing the system. In the first year of moderation, two schools out of twenty it was felt, merited some constructive criticism of the nature of the work submitted. The following year all of the schools were judged to be producing work which was in the spirit of the prescription and was appropriately assessed.

Scaling of marks is a significant, and controversial, feature of public examinations in New Zealand. It is defended on the grounds of inter-subject comparability and the need to combine marks from different subjects in determining awards. With regard to the Mathematics with Statistics examination the 80% examination mark had to be combined with the 20% practical, internally assessed component. The procedure used, which was consistent with the Board's policy of only combining marks with similar distributions, was as follows. For schools with three or more candidates the mean and standard deviation of the school-based marks were scaled to the mean and standard deviation of the raw scores of the school's candidates on the examination. The effect of this was to preserve the nature of the school mark distribution but it ensured that there was a correlation between the ability level of the class as a whole, as measured by the examination, and the school-based mark.

There are many arguments against the procedure. It is clearly unsatisfactory for schools with a small number of candidates, of which there are a significant number in New Zealand. It also makes the assumption that the examination marks are a "true" measure of performance and that project marks should be scaled to fit these. One could argue that in statistics the project marks are the more valid assessment and that, if

anything, the examination marks should be scaled to fit these.

A study of the effects of these scaling procedures on the school-based marks in the second and third year of their application showed that:

- (i) On average school-based mean marks were scaled down by 1.3 marks out of 20. This indicated that, in general, teachers had a higher opinion of the project work of their students than the examiners had of the students' examination work. My experience in moderating would support the teachers' opinion.
- (ii) 87% of the school-based mean marks were scaled within the range +1 to -3 out of 20. This seemed to reflect the reasonably uniform way in which the school-based component was being assessed and again this view is supported by the moderation experience.
- (iii) The mark distribution of a significant number of schools whose scaling was outside the range +1 to -3 did not meet the guidelines for marking suggested in the prescription. These were that it would be expected that at least two thirds of the candidates would gain marks in the range 8 to 15 out of 20.

These results seemed to indicate that although there were, and continue to be, significant misgivings about the scaling procedures used, their effect on the majority of school marks was not great. They also seemed to be dealing, in a reasonably appropriate way, with the marks from some schools whose candidates might have been unfairly advantaged or disadvantaged if the procedures had not been used.

4. Teachers' and students' views of project work

At the end of the first year in which project work was introduced all teachers and students were asked to complete a questionnaire on their experiences. The teacher questions related to organisation, the time taken in planning, preparation and assessment, class time allocated, student reactions and their feelings about the 20% weighting of the project. They were also asked for general comments and for lists of textbooks and resources used. The students were asked for the time taken in, and out, of class and for their general reaction to the project work.

As might be expected in the first year of operations, both teachers and students were feeling their way with project work and there was a wide variation in the amount of time which they devoted to it. In particular, the out of class time spent by students had a median of 20 hours but a significant number of students reported spending over 100 hours on their project. Similarly, the teacher planning and preparation time had a median of nine hours but again some teachers reported spending more than 100 hours on this aspect.

Teachers were asked to rate the motivation and initiative and the performance of their students in relation to project work. The results in Table 1 support the opinion expressed earlier that students had responded positively to the challenges of project work.

The students were asked if they found the project work more or less enjoyable, more or less valuable and easier or harder than the rest of the course work. The results in Table 2 also confirm the positive reaction of students.

TABLE 1
Percentage ratings by teachers of student motivation, initiative and performance on project work

| | Very Good | Good | Average | Poor | Very Poor |
|---------------------------|-----------|------|---------|------|-----------|
| Motivation and Initiative | 19 | 34 | 29 | 16 | 2 |
| Performance | 14 | 35 | 37 | 11 | 3 |

TABLE 2
Student comparisons of project work and the rest of the course work

The project work was:

| | | | | | |
|----------------|-----|----------------|-----|----------------|-----|
| more enjoyable | 56% | more valuable | 31% | harder | 33% |
| less enjoyable | 14% | less valuable | 27% | easier | 24% |
| about the same | 30% | about the same | 42% | about the same | 43% |

It is a pity that the demise of the examining body prevented a similar follow-up study after teachers had become more familiar with project work. However one might expect that with this familiarity the standard of work and the attitudes of both teachers and students would improve rather than deteriorate. Informal discussions with both teachers and students and the moderation experience indicate that this is the case.

5. Conclusions

The data collected as part of the monitoring procedures in the introduction of the project component into the examination indicate, quite clearly, that both teachers and students reacted positively to the change.

The real test, however, of the value of the introduction of the project component is not to be found in the quality of the projects produced, nor in the motivation of teachers and students. It might, after all, be possible to motivate students to achieve very highly in some activity which had nothing at all to do with statistics. The really important question, it seems, is: 'How has the introduction of the project component influenced the teaching and learning of statistics in schools?'

This question has been put to a number of groups of teachers in discussion situations over the last couple of years. Almost without exception they have responded by saying that the introduction of the compulsory project has been a very strong influence on the way they teach all of the course. They are constantly thinking, while teaching statistical techniques, how these might fit into student projects. This, more than anything else, justifies the introduction of project work into the examination.