Case Study: Evaluation of a University Mathematics Programme

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In developing a curriculum which is suitable for a diverse and changing student body, it is important to be able to evaluate how successful the existing programme is and how effective any changes are. In this paper we discuss a system which has been developed at the University of Auckland for processing examination marks, and how it can help in evaluating the programme.

Introduction

The rapidly changing nature of the student and staff population, technology, and the requirements and expectations of other disciplines has led to much reflection and debate on the the mathematics programme offered at The University of Auckland. Previously, courses were offered to a monolingual, same age cohort, homogeneous cultural and mathematical background group of students by a homogeneous staff for a slowly changing work environment. Now the students have different age, cultural, language and mathematical backgrounds. Meeting the challenges of such diversity through offering different types of course has been a typical response.

However, there are a number of questions. Have these changes been effective? Is the programme meeting the needs of the students? Is the programme coherent? Are the advice and information given to students regarding pre-requisites and performance expectations reliable? Changes to courses are currently made based on historical experience and professional judgement. But what effect do these changes have on the students' preparation for subsequent courses? All these and other questions were difficult to answer without easily accessible summary assessment performance data on all mathematics students. This paper reports on the consequences of developing an internet-based system for the storage and manipulation of students marks.

Programme Evaluation

According to the National Council of Teachers of Mathematics (NCTM) [1, p.66] "the primary question to be answered in any program evaluation is, How well is the program working in relation to the goals and expectations for the students?" They consider that a programme evaluation should use student assessment data with other evidence to judge the quality and success of a programme. However student summative data can be used for making decisions about whether a programme should be continued or be modified. According to Clarke [2] the monitoring of assessment data to inform consequent action is a fundamental purpose of assessment. In addition, according to NCTM, "an evaluation should consider any barriers that prevent students from attaining the full benefits of the program and what can be done to eliminate such barriers" [3, p. 238].

All students, regardless of language or cultural background, must have equal access to the full range of mathematics courses offered. Their patterns of enrolment and achievement should not differ substantially from those of the total student population. Programme evaluations should include indicators that the mathematics programme is meeting these essential criteria. Enrolment figures by gender, race, language and cultural background should be maintained for all mathematics courses. Access to courses this should be continually monitored and included as part of the ongoing programme review [3, p.239].

The NCTM [1] in their vision of reform suggest that programme evaluations should be based on evidence from multiple sources, such as the goals, the curriculum, the teaching methods, the environment provided for the students, and the professional judgements of lecturers, in conjunction with assessment data. However, since curriculum, instruction and assessment are inextricably linked a detailed analysis in the assessment area may provide information about where to investigate in the other areas.

What were our goals and expectations for the students?

The mathematics programme at the University of Auckland is based on a system whereby students choose a sequence of courses to meet their needs. In a year students normally do seven courses spread over a range of disciplines. This flexible system of choice of courses rather than compulsory courses creates the need to ensure that the system of courses delivers a coherent programme.

There was no existing written policy on the goals and expectations for students. Thus we used our own experience to write goals for monitoring standards and expectations for students in the programme. In this paper, we only consider assessment results (principally examination results) of the students. An investigation of these assessment data enables decisions to be made about whether the programme should be continued, changed or modified. The assessment results are not the only source of evidence gathered, nor are the particular goals discussed in this paper the only goals of the department. Each course is reviewed every three years and curriculum and pedagogical goals are incorporated in this assessment. The monitoring goals, objectives and performance indicators in one specific area of programme evaluation, in which the assessment results are used, are listed in Table 1.

Using these objectives we will now give some particular examples which illustrate how the development of internet-based system for storage and processing of students' assessment data has allowed us to evaluate and hence modify the mathematics programme.

Effectiveness of pre-requisites

It is important to be able to use results in earlier courses as an indicator of likely performance in later courses. For example, this enables staff to give good advice to students, and it indicates that the later course is fair. We illustrate this with 445.315 (Mathematical Logic), a stage 3 course which for many years has had disappointing results. One possible reason for this is that the students may not be sufficiently well-prepared. This course has "easier" pre-requisites than most other courses at stage 3: it only requires one course at stage 2 namely 445.225 (Discrete Mathematics). In contrast, many of the other courses require 2 stage 2 courses as prerequisites

Goal One: The programme of courses offered should enable a student to choose a coherent programme in mathematics or as a support for other disciplines.	
Objectives	**Performance Indicators**
The pre-requisites and recommended background for a course are sufficient preparation for that course.	Group students according to their preparation for a course. Compare pass rates of these groups.
The recommended grade for progression is sufficient for a pass at the next level.	Compare grades of students in a course with their grades in the pre-requisite for that course.
Potential future mathematicians are nurtured with a suitable sequence of courses.	Monitor participation and pass rates longitudinally.
Goal Two: The programme should be equitable for all students.	
Objectives	**Performance Indicators**
The standards and expectations for courses are maintained semester-to-semester and year-to-year.	Monitor grade distributions for each course and compare to previous semesters.
The standards and expectations for same-level courses are similar and consistent.	Monitor grade distributions for same-level courses.
The potential for success in a course is not affected by the particular choice of campus.	Monitor pass rates between campuses.
Results in a given course are consistent with results in pre-requisite courses.	Compare student grades in a course with the grades obtained in pre-requisite course(s).
The overall progress of individuals (including those who seem to have some difficulties) are monitored and investigated for any barriers that prevent them from obtaining the full benefits of the programme.	Look at record of an identified individual.
The overall progress of groups of students (e.g. race, gender, language, cultural backgrounds) are monitored and investigated for any barriers that prevent them from obtaining the full benefits of the programme.	1. Monitor participation rates. 2. Monitor pass rates and A grade rates and compare at same and earlier levels

Table 1: Goals, Objectives and Performance Indicators for assessment results

and some require 3. Thus there are a number of students who are permitted to take 445.315 but not many other courses at stage 3.

In the short term it is important to take this into account when considering the pass rates in 445.315, and addressing the question of whether expectations for same-level courses are similar and consistent. It would be inappropriate to try scaling the 445.315 marks to get a similar pass rate to other stage 3 courses if the reason for the lower pass rate is a weaker intake rather than that a harder exam.

In the longer term it is important to assess the appropriateness and sufficiency of the pre-requisite courses. One way to improve the 445.315 pass rates would be to strengthen 445.225 to make it a better preparation for stage 3. Changes were indeed made to this course in 1998. Using the new system, it was possible to compare the 445.315 pass rate amongst students from the "new" 445.225 with students who had passed 445.225 in earlier years. This comparison showed that the 445.315 pass rate was higher with the "new" 445.225 than with the old version. However, the improvement was not sufficient to get the pass rate (even for the "new" students) up to the expected range for stage 3 courses. Thus the Department decided to add a new stage 2 pre-requisite for 445.315.

An "Honours" stream?

Although the majority of the students in mathematics courses at stage 1 and 2 are not intending to major in mathematics, it is important to consider the needs of students who do intend to do so. It is not obvious how best to achieve this. The approach we adopted was to introduce an "Honours stream" of stage 1 and 2 courses to parallel the "mainstream" sequence. The 3-course Honours stream sequence covers the same material as the 4-course mainstream sequence, but with a more theoretical emphasis, and with less repetition of school material.

Anecdotal evidence suggested that most of the mathematics major students were not progressing through the Honours stream, but were coming from the mainstream courses, while the Honours courses were mostly catering for the more able students from other disciplines.

Integrating the assessment processing from several years into a single database made it possible to investigate this objectively. We found that, indeed, most of the students in our honours programme had come from the mainstream courses, and the Honours courses were withdrawn in favour of providing appropriate tutorial support for different levels of students in the mainstream courses.

Catering for students with different entry levels

Students come to the University of Auckland with different backgrounds in mathematical study, ranging from study at fifth and sixth form to good marks at seventh form level. Students in the latter group are directed into the mainstream sequence of courses, while students with only sixth form mathematics or with a poor mark at seventh form are directed into the bridging course 445.102 (Mathematics 2). This course is meant to bring such students to a level of knowledge and experience such that they will be able to cope with the mainstream courses 445.151 and above.

Courses 445.102 and 445.151 present a challenge in allocating grades fairly. On the one hand, given the entry requirements for the two courses, an A grade in 445.102 for a student without seventh form mathematics should represent the same level of achievement as an A grade in 445.151 for a student with seventh form mathematics. Thus the target pass rates and A grade rates in 445.102 are the same as those in 445.151 and 445.152. On the other hand, given that the material in 445.102 is more basic than that in 445.151, experience suggests that a pass in 445.102 (C−) is not sufficient to give a reasonable expectation of a pass at 445.151 the next semester. Thus the gap between the two stage 1 courses 445.102 and 445.151 is probably bigger than the gap between stage 1 courses and stage 2 courses. For example, Figure 1 shows, on the left, a scatter plot comparing results of the students who took 445.151 in a given semester with their earlier results in 445.102. The higher sloping line is a best-fit through the data points. It crosses the vertical line $x = 50$ at approximately $y = 70$, suggesting that the lower boundary for a C− in 445.151 corresponds to the lower boundary for a B+ in 445.102. In contrast to this, the plot on the right of Figure 1 shows a similar comparison between 445.251 and 445.152: in this case the upper line crosses $x = 50$ at approximately $y = 60$, suggesting that the lower boundary for a C− in 445.251 corresponds to the middle of the C+ range in 445.152.

The question of how to resolve this situation is still under discussion within the Department. However, the ability to compare students' results in one semester with results in previous semesters means that this can now be an informed discussion.

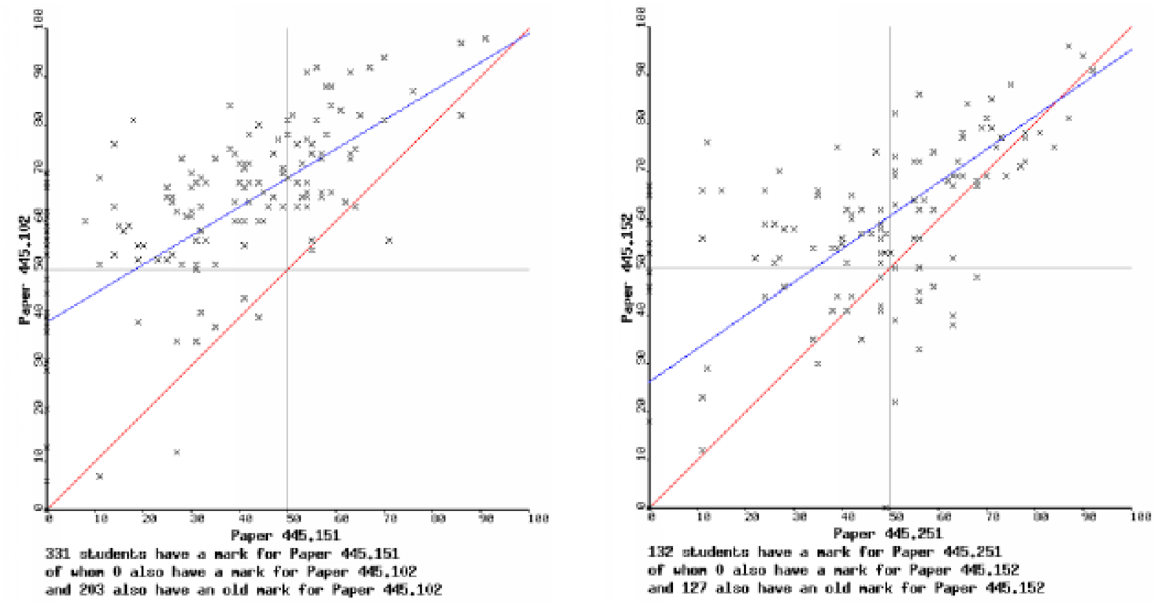

Figure 1: Scatter plots comparing results between 445.151 and 445.102 (left plot) and between 445.251 and 445.152 (right plot)

Conclusion

The programme evaluation discussed in this paper is based on one small aspect of assessment considerations. Assessment reform such as that described by the Mathematical Sciences Education Board [4] will take time in a university environment. However it is hoped that by starting with familiar assessment procedures lecturers can be drawn into discussions about assessment tasks, student learning and so forth. Further down the track, using this system and other sources of evidence, the consequence should be that lecturers will begin to raise questions about assessment methods and the type of tasks given to assess learning.

References

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