THE INSTRUCTIONAL IMPACT OF CHANGES IN ASSESSMENT

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If the use of assessment as a catalyst for systemic reform in mathematics education is to be justified, then research is required which links changed assessment practices with instructional consequences. Based on the Victorian experience, this study provides the first systematic investigation of this hypothesised "ripple effect". This paper reports the results of the document analysis which comprised the first stage of the study. The analysis of documents relating to the mathematics curriculum, teaching practice, as well as to assessment and reporting in mathematics from eleven Victorian high schools revealed extensive adoption of the distinctive features of the Victorian Certificate of Education (VCE) Study Design (VCAB, 1990), and its multi-component assessment scheme. The document analysis charts the impact of these changes in nomenclature on the structure and practice of the mathematics curriculum in Years 7 to 10. The first stage of the study strongly confirms the impact of changed assessment practices in Years 11 and 12 on curriculum policy and practice, and on how mathematics is taught and assessed throughout secondary school.

Assessment is being conceived both in Australia and internationally as a catalyst for systemic reform in mathematics education. Experiences in Britain and Australia support this view; where it is suggested that changes in mathematics assessment at the senior secondary level have been associated with extensive changes in instructional and assessment practices throughout the school system. This curricular "ripple effect" has yet to be demonstrated by any systematic study.

The recent history of mathematics assessment has been primarily directed towards increasing the degree of correspondence between the intended curriculum, the taught curriculum, the learned curriculum, and the assessed curriculum. In the past, countries such as Australia in attempting to assess the taught curriculum have limited their assessment to timed and written tests, where the major focus has been on facts or skills. It is becoming increasingly evident that exclusive reliance on this form of testing is inappropriate: misrepresenting mathematics, at odds with contemporary curricula, misleading in the information it provides teachers, and potentially destructive in its effects on some learners (Clarke, 1992).

The alternative vision of mathematical behaviour, which can be found in contemporary curriculum documents (AEC, 1990; NCTM, 1989), demands an alternate vision of assessment. The realization of such a vision requires tasks which provide pupils with the opportunity to engage in mathematical thinking in a variety of forms and contexts, and at different levels of sophistication.

Attempts to model mathematical behaviour in assessment systems have recently led to the development of multiple-component systems, such as the senior secondary mathematics assessment in most Australian states. In the Victorian Certificate of Education, which forms the focus of this study, students complete a multiple-choice skills test, an extended answer analytic test, a 10-hour "Challenging Problem", and a 20-hour "Investigative Project" (Victorian Curriculum and Assessment Board, 1990). Each of these components is weighted equally in its contribution to the final grade, and all are intended in their totality to model mathematical behaviour in a variety of

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contexts and forms. Similar innovations in assessment have been introduced in other Australian States and Territories.

Application of the "ripple effect" argument is predicated on a belief that curriculum, teaching practice, and forms of assessment in the junior and middle secondary years will replicate practices arising from the implementation of changed assessment at the senior secondary level. However, the question remains as to whether teachers of junior and middle secondary mathematics find in this expanded range of assessment practices and the instructional correlates an opportunity to increase the effectiveness of their teaching, or simply additional administrative and organizational burdens, which increase their workload in ways that ultimately reduce rather than enhance the quality of their instruction.

In their evaluation of the VCE implementation after three years, Northfield et al. (1992) report that:

> Almost without exception teachers of Year 7 to 10 indicated that there were changes in work practices of junior students as a result of the VCE. Many schools were introducing the terminology of VCE. Work requirements were being specified commonly in Years 9 to 10. Some extreme cases have seen work requirements and even CATs [Common Assessment Tasks] introduced as far down as Year 7, although one suspects that, in many instances, this is little more than renaming an end of term test as a CAT.
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> (Northfield et al., 1992, 31-32)

Our study suggests that the extent of change in instruction and assessment practices is much more than the "nominal change" (Romberg and Price, 1984) implied by Northfield et al. In all schools participating in this study the end of term tests were no longer the only form of assessment. In all schools, assessment through substantial problem solving activities or investigations had become a significant component of a much more elaborate assessment scheme than had been in operation prior to the introduction of the VCE. In some schools, end of term tests had disappeared altogether, although the assessment of conventional mathematical skills and applications continued through various forms of continuous (that is, progressive) assessment, alongside the assessment of problem solving and investigations.

THIS STUDY

The research discussed in this paper comprises a study into the instructional effects in Year 7 to 10 mathematics classes of changed assessment practices in the senior secondary years. It is anticipated that the findings and the methodology employed in this study will be applied in similar studies in other Australian states and that the study itself could be replicated in the United States.

Sample

Schools were selected by a process of theoretical sampling to include the following characteristics: rural and metropolitan; government and non-government schools; and social demographic characteristics (including ethnicity and language). The variation in Victorian schools with respect to these characteristics has been encompassed effectively in a sample of eleven schools. Only schools providing instruction for Years 7 to 12 were included in the sample.

Method

This study used interviews, questionnaires and the analysis of relevant documents. The intention is to obtain sufficient data to adequately portray current practice on each of the school sites, and also to document the recent origins of current practice, and the immediate consequences of the introduction of the VCE.

Three sources of data have been used: documentation of school curriculum policy and practice, including work samples from teachers and students; interviews; and a questionnaire. In this paper we report the results of an extensive analysis of curriculum documents provided by participating schools. The method by which this document analysis was undertaken is set out below.

Document characteristics

The following sources of information were requested from the participating schools in order to indicate significant aspects of mathematics teaching in Years 7 - 10 which could be associated with changed assessment practices in senior mathematics:

- course planning documents (eg course outlines, syllabuses)
- information to parents/students regarding course options and requirements
- sample assessment tasks
- sample of student assignments and project work
- school report forms
- teaching notes
- other school developed support material for teachers

In addition, school communications with the researchers provided further valuable data on the practical implementation of assessment-related curricular changes.

Content analysis

Each document was analyzed with respect to the occurrence of key terms (words or phrases). For the purposes of this study, a term was considered significant if it met either of two criteria:

- the term represented a change in practice
- the term matched a corresponding term found in VCE documentation

Lists were compiled of such significant terms, grouped initially according to the source document. Within the compiled lists of terms, it was possible to distinguish three categories of curricular change:

1. Change in nomenclature (terminology)

For inclusion in this category, the use of a term in a school document was taken to represent change at the level of description, without necessarily implying a consequent change in practice.

2. Change in structure

Some terms could be taken as indicative of new structures for assessment and instruction. For example, the specific inclusion of investigative projects and problem solving tasks as separate components of school-based teaching and assessment represented a structural change in the school mathematics curriculum. The degree of change at the level of teacher or student practice could not be inferred necessarily from the structural inclusion of such elements.

3. Change in practice

Terms such as "predict", "model", "draft and re-draft", and "format" (in relation to the writing of students' reports of extended projects or problem solving activity) indicated changes in both teacher and student classroom practice.

RESULTS OF THE DOCUMENT ANALYSIS

Documented change

The results of the document analysis can be reported as indicative of change in four key areas: Policy; Curriculum and Teaching; Assessment; and Reporting. Analysis of the occurrence of "Work Requirements" in the various documents is used in the following discussion as an illustrative example both of the methodology used in this document analysis and of the manner in which elements characteristic of VCE mathematics assessment find their embodiment in each of these four key areas.

Changes in Policy

The VCE *Mathematics Study Design* frames a curriculum in terms of specific Work Requirements. These prescribe the sorts of activities in which students must engage for the satisfactory completion of classwork. In their course planning for Years 11 and 12, teachers are required to allocate significant proportions of classtime to all of the work requirements. There is also a direct correspondence between the work requirements and the components of assessment. In mathematics, three Work Requirements are specified: Investigative Projects; Problem Solving and Modelling activities; Skills Practice and Standard Applications.

In their policy documents for Years 7 to 10, all eleven participating schools had adopted the VCE terminology of "Work Requirements" with respect to extended mathematical projects, problem solving, and skills practice and standard applications. Documents such as the "Year 7 Information Booklet and Course Details" from one school

specifically listed as "work requirements in order to achieve satisfactory completion of a unit" such activities as: "set exercises", "project work", "problem solving", "a written summary of work covered", and a "self assessment".

Changes in Curriculum and Teaching

Within course documents produced by the mathematics departments, these work requirements were elaborated for students and teachers in very specific terms strongly resembling those used in VCE curriculum documents. One school mathematics department included "Problem Solving Teaching Notes" with subsections such as "Some suggestions on how to teach problem solving", and "Problem Solving Student Notes" aimed at clarifying the nature of mathematical problem solving activity and the demands of non-routine mathematical tasks.

Changes in Assessment

Changed assessment practices were evident in:

- the tasks which comprised a school assessment package;
- what students were expected to do in those tasks; and
- how the tasks themselves were assessed.

All schools made specific mention of work requirements in assessment-related documents. In all schools, the assessment of problem solving and projects, together with the assessment of standard mathematical skills and applications, had been incorporated into the formal structures of assessment and reporting.

There is overwhelming evidence from the data collected in this study that, as in the VCE, assessment explicitly included reports of problem solving and projects. These activities are substantial, ranging from short one-page reports or summaries of a problem solving activity in Year 7 to more extended reports in Years 9 and 10. In these Years, the procedures for developing a report, and the suggested format for reports, more closely resemble those required for the VCE. At one school "Consultations and evidence of drafting" were required to be recorded by students in Years 9 and 10 submitting reports of problem solving or investigative project work.

A key feature of the Investigative Project CAT in the VCE is the use of the project report format, which sets out not only the headings under which the report should be prepared but also key mathematical elements that are to be included. The project report format at one school specified key mathematical considerations to be included in the various sections. For example, in the section labelled "Conclusions" we find the following:

> In this section, the results of the project should be brought together, evaluated and related to the stated aims. The conclusions should include discussion of the more important limitations of the investigation and possible further investigation suggested by the results.

In preparing a report of a problem solving activity, students at this school are required to present not only a solution, but to give explicit attention to a statement of the problem, the solution process which they have followed, and to carefully justify both the solution and the steps which have led to it. The similarity with VCE assessment requirements is obvious and quite deliberate.

In assessing reports of problem solving activities and investigative projects, teachers almost without exception have adapted the criteria for assessment of the corresponding components in the VCE. The number of separate criteria is frequently reduced, and are sometimes tailored to suit a specific problem solving assignment. For example, in the assessment of a Year 8 project on Pick's Rule, eight criteria were used, each being graded, as in the VCE, as Not Shown, Low, Medium and High. The use of the VCE coding Not Shown, Low, Medium and High appeared to be quite general among the schools sampled.

Changes in Reporting

The recognition by schools that their reporting practices had changed was evident in the information conveyed to parents through school handbooks about the content of student reports. The significant changes in reporting appeared to include:

- report format;
- the nature of the student activities reported upon; and,
- the manner in which the information was conveyed.

The most common practice in report format was to provide separate assessments for each student on Skills and standar applications, Projects, and Problem solving; that is, for precisely those work requirements specified within the VCE.

One school reported to parents on "Group investigation and oral reports to class". Evaluative and numerical grades were provided on the "Oral presentation", the "Prepared written presentation", "Research undertaken - depth, breadth and appropriateness", "Explanations and answers to questions", and "Use of mathematics and conventions" in the pro-forma employed in reporting to parents. This explicit acknowledgement of aspects of student mathematical activity which had not previously formed a part of school communication to parents can be explicitly linked to the VCE.

The expression "Satisfactory completion" was frequently found in school reports. Letter grades were combined with descriptive assessments. Often, skills and applications were reported separately for the different content areas covered during the term or semester. A new assessment vocabulary was in evidence, and this vocabulary could be traced directly to VCE terminology and practice.

A new vocabulary

The introduction of the VCE involved, to some extent, the adoption of a new language by which mathematical activity could be described. Terms like "mathematical modelling", "justification", and "draft-redraft" had not previously been current in either school curriculum documents or in the day-to-day discourse of classroom teachers. Each of these new terms required not just the assimilation of a new label for an existing activity or practice, but in many cases represented a new agenda for classroom practice and assessment. The new language was concerned as much with process as with product. At the level of the VCE, teachers had no choice but to learn how to use this new language. There was, however, no obligation upon teachers to employ the same language to describe or assess the less sophisticated mathematics of Year 7. Analysis of school documents revealed that terms derived from the language of the VCE were used to describe and guide student mathematical activity at all levels of secondary schooling, from Year 7 onwards.

Significant terms in general use included: explain and discuss; find a model; predict; give a justification; starting point or scenario; research proposal; planning document; and evaluation of conclusions. These terms accord value to a broader conception of what is to know and do mathematics. It is a non-trivial consequence of the VCE to find reference to these higher-order processes consistently occurring in relation to junior secondary mathematics.

IMPLICATIONS OF THE STUDY

Implications and interpretations

Northfield et al. (1993) have argued that "academic schools" would be more likely to be concerned with some of the assessment procedures and whether the VCE could extend the more able stiudents (cf p. 81). Indeed, it could be argued that changed assessment procedures and practices within the VCE might be confined to changes in assessment in Year 7 to 10, with very little flow-on to day-to-day curriculum and teaching. Among the schools studied, the procedures used to assess problem solving activities and investigations did reflect assessment criteria used for these components of VCE mathematics, usually modified according to year level and background of students. used. In all cases, however, there was an explicit link between assessment and teaching, with substantial classroom time being spent on problem solving activities and investigations, in explaining to students how to approach these tasks, and how to prepare a written report of their mathematical activity.

In the study coordinated by Madaus and West (1992) into "The influence of testing on teaching Math and Science in Grades 4-12" the views of 2229 teachers were sought. The minimal reported influence of standardized tests and textbook tests contrasted with reports of "test pressure and test-oriented instruction" associated with mandated "high stakes" testing programs (Madaus & West, 1992, p. 7). The Madaus and West study based its conclusions on questionnaire data and an analysis of tests representative of those cited by respondents. The study identified differences in the prevalence of "test-oriented instruction" in different classrooms. Questionnaire analysis in the next stage of this study will identify whether such differences occur between Victorian schools and classrooms. Interviews with teachers will help to detail the values, beliefs and motivations behind any such differences and, where appropriate, relate these to the influence of the VCE.

Some terms found in contemporary writings in mathematics education, such as "problem posing" or "journal writing", were not employed in VCE curriculum or assessment documents. The absence of these terms from the

school documents analyzed suggests that the documented changes can be attributed to the VCE rather than to a response by teachers and schools to more general changes in the professional literature or in the educational climate. The consequent hypothesis is that unless a term or a practice receives the explicit sanction of inclusion in high stakes assessment it is unlikely to influence school policy or classroom practice.

Anticipating Stage Two: Questions to be addressed.

In the next stage of the project, comparison will be sought from all respondents with regard to experiences prior to and during the introduction of the VCE. In particular, the study will document respondents' perceptions of the changes in administration, curriculum planning, classroom instruction, and assessment in the junior and middle secondary years, which are perceived as being linked to the requirements of VCE mathematics.

The detail of changes in practice, which have been inferred from the document analysis, will be reassessed through questionnaire and interview. The stage two analysis will also determine the extent to which the documents provided exemplified typical classroom practice in a school. It is important to establish the strength of the link between changes in instruction and assessment and knowledge of the practices required by the VCE. In this respect, we need to ascertain whether the translation of VCE terminology and practice into junior secondary mathematics classrooms is more pronounced for those teachers who have had experience teaching the VCE.

> As with any new change, different people embrace it at different rates and some of our staff use almost no project/problem solving activities at years 7 - 10.
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> (Mathematics Coordinator at one of the study schools)

As noted, the absence from school documents of certain terms and practices, endorsed by the academic and research community, but not given prominence in the VCE, will provide an important key through interviews into an understanding of the priorities, criteria and values by which teachers decide which innovative practices to implement and which to ignore. It is quite possible, of course, that it is only through such dramatic change in assessment practices that the contemporary reconceptualisation of school mathematics (cf. AEC, 1992; NCTM, 1989) has been brought to the attention of classroom teachers.

If the use of assessment as a catalyst for systemic reform in mathematics education is to be justified, then research is required which links changed assessment practices with instructional consequences. Based on the Victorian experience, this study provides the first systematic investigation of this hypothesised "ripple effect".

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