

## INNOVATION IN SENIOR SECONDARY MATHEMATICS CURRICULUM: THE VOICE OF THE TEACHER<sup>1</sup>

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Educational reform is currently being implemented right across the globe at both the National and state levels in an effort to change classroom practice (Hiebert et al, 1996). The Victorian Certificate of Education (VCE), introduced fully in 1992, is one example of this development, where changes in assessment practice have been used to bring about reforms in teaching at the two most senior years of secondary schooling. Its structure and requirements anticipated modified classroom practices through changes to both the standard curricula and to the assessment tasks set. The American literature has made frequent reference to "Measurement-driven instruction" (MDI) (Airasian, 1988), and in many ways, the VCE provides a good local example of MDI. In this paper we look at the impact of the VCE on teaching practice and on the professional lives of mathematics teachers, reporting, as far as we can, the perspective of the mathematics teacher. While research on the VCE in general has focussed on the perceptions of participants (Northfield & Winter, 1993), research on VCE Mathematics has had a particular emphasis on statistical data relating to patterns of achievement under the new system (Cox, 1993, 1994; Rowley, Brew & Leder, 1994; Rowley, Brew, & Ryan, 1996). The data reported in this study, we hope, will lead towards a deeper understanding of the way in which assessment-driven reform affects the practice of the teacher.

Historically, the successful implementation of educational innovations has often been thwarted because teachers lacked a clear understanding of what was expected of them (Gross, 1971). Fullan (1982) argued that attempts at educational reform frequently fail because attention is given to policy-making and not to developing an understanding of how to work through a process of change. In this study, we focus on teachers' perceptions of what was expected of them and on the way in which they have altered their teaching and their views about what is good mathematics teaching. By doing so, we hope to contribute to an increased understanding of the processes of change that have occurred.

### The Victorian Certificate of Education

The Victorian Certificate of Education (VCE) specifically endorsed the notion of curricular choice within a defined framework. Subjects were replaced by Studies, in which schools developed their own specific curricula (within tightly defined frameworks) to suit the varied needs of their own students. In mathematics, a total of six Studies was offered. Each study was required to be examined by Common Assessment Tasks (CATs), spread throughout the year, rather than by a single examination at the end of the year. In the case of mathematics, four CATs were prescribed:

CAT 1 was an investigative project, centrally prescribed, but administered and marked by teachers. From a given theme, students developed a project to demonstrate the application of mathematics in the areas studied. The students are guided in their choice of focus and also in the way they allocate their time over a number of weeks by their teacher. They are allowed to work in partnership or in small groups, as long as each student completes the analysis, interpretation and writing-up individually.

CAT 2 was a challenging problem where each student chose one of four questions provided. A specific format for writing up the results was required that included two sections, 'Solution and Justification' and 'Solution Process'. Students were allowed two weeks to solve the problem. Teachers could provide general advice on problem-solving

strategies, but not specific information to solve the problem at hand; only the students' interpretations and analyses of the problem were acceptable. Like CAT 1, the tasks were centrally prescribed, but administered and marked within schools.

CAT 3 was an examination of skills and applications, and was more in keeping with traditional modes of assessment. The assessment focus was on examination of factual knowledge and on the students' ability to choose and manipulate appropriate algorithms. The format of the examination was multiple choice, and it was completed in 90 minutes under examination conditions. Each Study had a core section answered by all students and a second section, which contained a number of modules from which students chose four. The modules provided for a level of choice, although the choice was not necessarily made by the students. The modules studied by the students were chosen by each school.

The focus of CAT 4 was assessment of the students' analytical abilities. Extended written answers were required. While completed under similar examination conditions to CAT 3, with 15 minutes reading time and 90 minutes writing time, students were allowed to take in pre-written notes restricted to four pages.

The broadening of the assessment tools was a particular feature of the curriculum reform, and the range of choice was intended to cater for a wider range of students under the one certificate of achievement (the VCE). The curricular reforms took place within an environment of budgetary restraint, tight competition for tertiary entry, and a tradition of statewide examinations, supplemented over the previous ten years by moderated teacher assessments. Consequently, although the curricular reforms promised a reduced emphasis on statewide examinations, there was never a serious likelihood that the examinations would be discontinued. In mathematics, particularly, the change was controversial. Since its implementation in 1992, it has captured the attention of the press, and twice has been subject to major changes.

Current research

Our first research was based on quantitative data. We obtained

assessment data from the Victorian Board of Studies (VBoS), and subjected it to extensive statistical analysis (Rowley et al, 1994; Rowley et al, 1996). Early findings included the following:

- (Girls generally performed much better than boys on projects and extended problems
- (Boys generally performed a little better than girls on examinations.
- (Girls obtained better grades overall.
- (Non-English speaking background students performed better than English speaking background students on all four types of assessment.
- (Where choice was allowed, some options were much more difficult than others.
- (In making their choices, some students chose options that their school did not teach!

Most of these findings were the opposite of what many people would expect. The quantitative data did what quantitative data do best - they told us "No, things are not exactly as you expected." The current phase of our research involves qualitative data and is intended to provide insights into the experiences of teachers who have been involved in the implementation of the new curricula.

#### Methodology

To obtain information about the impact of the changes augmented by the VCE on teachers and their classroom practice, we selected a wide range of school types (see Table 1) with the aim of obtaining a broad representation of views rather than a statistically representative sample. Of forty-five schools approached, forty chose to be involved in the study; two principals declined to be involved and three teachers

failed to attend scheduled meetings.

Table 1: Profile of schools in the study

SCHL TYPE	No.	Sml(<600)	Lge(>600)	Rural	Mpolitan	Co-ed	Girls	Boys
State	23	7	16	4	19	21	2	0
Catholic	9	2	7	2	7	4	1	4
Independent	8	4	4	2	6	3	3	2
Total	40	13	27	8	32	28	6	6

All the teachers interviewed were involved in teaching Year 12 mathematics, and were VCE mathematics coordinators or held comparable positions. Typically, the teachers were highly experienced, particularly at the VCE level, and many had been for long periods in their present schools (Table 2). The majority (70 percent) were male, which reflects the proportion of male mathematics graduates generally. Their qualifications ranged from a basic science degree to a Masters degree.

Table 2: Profile of teachers interviewed in the study

### Teaching experience (years)

Total		Years 11&12		Time at cur scl		Gender	
Mean	Range	Mean	Range	Mean	Range	Male	Female
18	6-30	15	6-30	11	2-25	28	12

Most interviews went longer than the scheduled hour and the questions were few and broad, as our intention was that they would serve as prompts to get the teachers talking about the issues that both interested and concerned them.

### Analysis of the data

Our first step was for each member of the team (five in all) to write down independently a list of propositions that he/she thought seemed likely from their knowledge of the data. We then met, compared what we had done, eliminated the many duplications, and eventually arrived at a very long list of propositions, not all of which we agreed with, but any one of which might or might not become part of our conclusions. On examining the list, we found that there were common themes, and we sorted the propositions into groups based on those common themes. The themes that emerged were

Professional practice (including professional development)

Curriculum

Choice

External influences

Gender issues

ESL student issues

Assessment

Student learning issues

Workload issues

The results reported in this study focus on the first of these themes.

A longer report (forthcoming) will cover all nine.

### Professional practice

A major concern of the study was that teachers should reflect on the extent to which they have changed the way that they teach mathematics as a result of the curriculum innovation. More than half of the 40 teachers indicated that they had, and most of these spoke very positively of the changes. One teacher commented that the VCE, ... is fresh. I think it is much better; if it hadn't happened I think

maths would have just kept dragging along.

But how have teachers changed? In many ways, no doubt. One considered that the curriculum reform had enabled him to aim for outcomes that went beyond the mechanics of mathematics that he had previously found sufficient to "succeed" -

I did find for a number of years that we got great results but the kids were good technicians. Give them something that they had never struck

before and they say "we haven't been taught this," end of story. But now I think we are starting to get to a stage where we are more prepared to have a go at something .... it wouldn't have happened if we weren't forced to do it.

"It wouldn't have happened if we weren't forced to do it!" This admission was typical of many teachers who have embraced the new curriculum with some enthusiasm, but would not have changed had the assessment system not made it necessary. A second teacher reflected that

We like the problem solving, we like the investigate projects, and I think back to years and years ago, I just taught the kids and the so called kids learnt. I am glad those days are gone and we spend a lot of time problem solving and we like it.

However the mode of teaching encouraged by VCE makes heavier demands on teachers, and many of our respondents, while accepting this commitment for themselves, were concerned about the unwillingness of some colleagues to give the same level of commitment. One remarked that, Some of my colleagues are conservative, teacher-centred, chalk and talk - Teaching is nice but it is just a job, and "Why are you worrying and thinking about these things, you are making it too hard and dwelling on it - get a life!" ... My attitude makes me perhaps more willing to try new ideas, discuss them and evaluate them. ... When you change you get a group of people who resist it and another group of people who say "This is interesting, I am willing to look at this."

Another issue for some teachers was the pressure to teach for examination and project-writing techniques, rather than (or in addition to) teaching mathematics.

The nature of the work requirements has caused us to modify the approach which was used prior to the VCE. There is a need to show the students how to produce solutions to problem solving activities, and how to tackle major projects, so that has involved some difference. The same teacher saw a need to revert to more orthodox means of teaching in the face of pressure to complete a body of mathematical content:

But when you look at the syllabus that the students have to complete, ... you can't leisurely introduce work when you have a chapter to do in two and a half weeks. ... We are forced into a traditional method of teaching and I haven't seen any of what you would call "innovative teaching" for sometime, simply because of the time and pressure constraints of covering the work.

Another response to the conflicting demands made on teachers was to "compartmentalise" their teaching. One teacher distinguished the tasks required for teaching the VCE course from "real" mathematics teaching, and described his ability to switch from one mode to the other, as required:

I suppose having a lot of our work around project and problem solving it meant a difference. It has simply meant (though) that most teachers tend to do it in chunks, (like) today we are going to work on the project and tomorrow we are going to get down to real teaching again. "Reluctant acquiescence" is probably an accurate description of the

response of many of the more traditionally-oriented teachers in our sample. Very few declared themselves opposed to the curriculum change; most could see good in it but many felt that the conditions were against them in their attempts to implement it. Of the 40 teachers that we interviewed, nine were insistent that very little had changed

in their own and their colleagues' teaching practice. One said of his colleagues that "they are just doing the same thing in a different system." Again the pressure to get through the syllabus was said to be the main reason; as another teacher commented:

Just watching their (other teachers) preparation I don't believe it has changed a great deal, that is just an observation, and things that you pick up as you walk past (classrooms) and see what is going on. ... In (Year 12) you just do not have time to do those innovative things, ... as much as you would like to try it.

Other teachers maintained that the VCE had led to no great changes in their teaching, because the innovative techniques had already been integrated into the curriculum prior to the introduction of the VCE. For these teachers the role of the VCE had been to legitimise their teaching practice.

There is more emphasis than before on projects and problems but not a great deal because ... we have been teaching projects and problem solving in the school right through from Year 7.

Just one of our respondents was clearly more comfortable with a traditional teaching approach and looked for opportunities to continue in this way.

Heavily teacher directed is the way that I was taught and the way that I am comfortable with. With Maths Methods there is a lot of calculus which is very traditional, the graphing is reasonably traditional and can be taught in a fairly traditional way.

Although only one spoke in these terms, it was apparent from their comments that many more had colleagues with similar views. But it remains a minority view in our sample.

#### The impact on years 7 through 10

Quite unexpectedly, we found substantial evidence that the changes to the years 11 and 12 assessment had altered both the assessment patterns and the classroom practices in years 7 to 10. Several respondents commented that the greatest impact was on years 7 through 10, where the pressure of tertiary selection was not present. One teacher, who had expressed enthusiasm for activity-based learning at the junior level, appeared to have abandoned the idea at year 12: At this level, a predominantly traditional teaching practice had persisted because of the perceived pressure to get through the curriculum. For example: There is a lot less chalk and talk than there was, especially in the junior levels - a lot more activity based learning. (At) VCE level, there is still a lot of chalk and talk as you have to get through the course.

Leading up to the CATs I just go flat chat teaching stock standard work

because there is a real rush prior to that project. ... It is chalk and talk and heads down to get through all that work ... you have to go solidly.

Many teachers saw the pressure of year 12 as a major factor inhibiting them from committing themselves fully to the mode of teaching encouraged by the new curriculum structure.

Problem solving I think was the best innovation which filtered its way down the school so we now have specific problem solving exercises from Year 7 up. So that has been good. It certainly has changed teachers' attitudes to the importance of problem solving and projects and that has been good. I think at the top end it hasn't worked as well ... . The stifling effect of extreme competition in years 11 and 12 has yet to penetrate the junior years, at least in the schools from which we drew our data.

Despite the apparent impact on years 7-10, several teachers reported that the pace of change at the junior levels had been substantial in the initial few years but that this had now been curtailed or even reversed. The reasons given for this included not only the workload involved but pressure to resume more traditional forms of assessment

and in the case below this pressure was attributed partly to parents. It has changed mathematics right through down probably as far as year 8. There was certainly an enormous change two years ago. I think a lot of that has gone by the board now because people have cut back a lot of the project work because of the time features. I know I was doing a lot more project work three years ago compared to now. We are still trying to fit that in, but it is purely lack of time nowadays, there has been a real return to some extent to exams and tests because the pressure to get results there. There is a pressure for kids to have a test percentages which the parents can look at.

Changes of this nature from years 7-12 place substantially greater demands on teachers, and this was the aspect that troubled some of our respondents, one of whom remarked:

One big problem with that is the VCE is enormously time consuming to do it correctly, and one result of this is that (because of) the workload, a lot of people are paying lip service to this. They will do the projects and unless you happen to have some time off, well, you tend to pay lip service to it. ... I mean realistically, if you are going to do a Year 10 class and do the projects correctly, you have created 10 hours work. Now to put in 10 hours at one class and then you have to do similar things at Year 7, 8 and 9, you are looking at a phenomenal workload, so you have to rationalise things. ... If you put the time into doing the marking, you cut back in your class preparation, and you have to prepare the classes well or you just wreck the actual teaching program. So it becomes a balancing act, and you just have to cut back in some areas. So you can't run a high quality program and cut the guts out of it which is what is happening.

There appeared to be among teachers in the junior years of secondary, a perception that the quality of their teaching was being held back.

They felt they were not delivering to students the programs that they believed were necessarily to prepare them for the VCE. Other respondents felt that their efforts to bring about improvement at the junior level were hampered by the lack of knowledge of some of the junior mathematics teachers of the VCE program and their resistance to innovations.

In at least two other schools, senior mathematics teachers, partly anticipating the increase in workload, but also concerned about the need to change their teaching style, were opting to teach at the Year 7-10 level only. An interesting outcome of this shift was that rather than persist with traditional methods of teaching at these junior levels, these two teachers had voluntarily begun to alter their teaching styles adopting the VCE's innovative approaches. So while the senior school had lost some senior staff, the middle school had benefited from obtaining not only a greater input from more qualified staff but gaining greater assistance for students in their preparation for the VCE. It was described in these terms by the mathematics coordinator:

There was one teacher who is not teaching VCE now. I don't really know his proper reason, (for doing this), he just opted out. He ... had been around for a number of years, and he could see that there was going to be an increased work load. So he went back to Year 7 to 10. ... He is a good teacher; it is funny, with the strategies for Year 7 to 10, he gives the kids work requirements and he really sets it up like the VCE.

But other teachers appear to have retreated to junior classes as a result of not feeling fully comfortable with the problem-solving/project approach of the VCE:

One teacher feels that he is going to retire in the next year or so and he didn't want the work load of Year 12 VCE, although he has taken year 12 in the past when projects and problem solving weren't involved and he was very happy to teach that. And that is why he enjoys teaching and is happy to teach. He hasn't liked to get too involved with problem

solving and projects, investigative tasks ... .

For some teachers there was also a perception that the changes in the junior school had gone too far. The following comment came from a teacher who earlier in the interview had indicated no great enthusiasm for the VCE generally.

For years I have tried to go along and implemented the systems and get along with everything, and in fact it could be argued in this school that we have implemented it far too much, right down to Year 7, with work requirements, report writing, the facts and skills, problem solving and projects.

A different perspective on this issue was a perception that the influence of the VCE on the junior years was going to interfere with an already established innovative individualised program. At one school the VCE was seen as reinforcing a more traditional form of teaching in the junior years.

(We have not changed the way we teach) at VCE, we have changed the way the we teach from (Years) 7 to 10, but VCE is getting in the way. ... We adopted a system where everybody does their own thing at their own speed all continuously assessed. ... What you become is a person who diagnoses individual problems and finds an individual way around it, each one of them is a case management system. (So) we would like to teach individually and VCE as well, but because of the administration associated with it, it might prove difficult. ... That ties you down to teaching in old-fashioned ways.

Inadvertently, the changes in year 11 and 12 may have altered the balance of staffing between junior and senior classes in many schools. Although it is usually seen as desirable for teachers to spread their teaching over the senior and junior years, in many schools the realities of staffing had meant that senior mathematics had been monopolised by a few senior staff. The perceived workloads associated with the teaching of the new VCE courses caused some reappraisal, and some staff moved their teaching partly or fully from the senior to the junior years. From our sample, ten teachers said that this had occurred in their school, and another ten said that there were colleagues who wanted to and who resisted teaching at the senior levels. The increased workload was said to be the most significant factor creating resistance, although, as already discussed, the pressure to change teaching practice was another.

Yes, (though) I have only struck it two or three times. I think the work load scared them. There was an enormous work load initially, and people have either got used to it or adapted themselves to it, but in the early years it was an enormous work load.

Yes, we have lost teachers, but whether they would admit to it being because of the VCE I don't know, but we have, yes.

... there is a certain reluctance to teach it (VCE) because of the time consuming nature, that quite a few people said, when it first came in ... they didn't want to teach VCE, "I think I will go down to Year 10 level," and "what are the opportunities at Year 7 - 8?"

Professional development

Innovation without professional development support is usually seen as a recipe for failure. In this case, the innovation was introduced at a time of considerable budgetary constraint at the state level, and its implementation has suffered criticism because of the perceived lack of professional development opportunities for teachers. But this did not prove to be as big an issue with the teachers we interviewed as we had expected. Indeed, 13 of the 40 teachers indicated that there was a reluctance by mathematics teachers in their school to attend inservices. One commented that,

We have a good professional development scheme at the school if they chose to use it. ... (My) general observation of teachers at the moment at the VCE level is that they are exhausted. They don't feel like giving up their own leisure time any more. We are sending people

to MAV every year, and we are sending people to inservices at night.

The problem is that the teachers are very happy to have something during school time but not after school.

Five teachers indicated that inservice attendance after hours, while not frequent, did occur at their schools. Clearly some schools were more supportive of teachers using school time to go to inservice activities. The following comments refer to different schools:

I have to encourage them. The opportunities are there. The opportunities were there for (two teachers) to go to the December (Mathematical Association of Victoria) conference this year, but they chose not to.

There is a lot around and some teachers don't take it up. ... The school here is very generous and always has been in regard to that. Professional development does not just occur in response to attendance at courses and conferences; in fact many would argue that the best professional development occurs in informal settings. We found encouraging evidence that the process of change has fostered greater communication among mathematics teachers, and that this has been a powerful source of support. Sixteen teachers said there had been an increased level of communication among teachers, as a consequence of the VCE. A teacher in a rural school described the process in these terms:

Well we have a cluster of schools which work together, we meet ... at the pub and sit down and say "these are the sorts of questions we have been asked". ... We meet just at the beginning of the CAT and say "how do you approach this sort of question, and what do you think they are asking for here?" Some of them say "well I rang up and got this piece of information" and they share that. When it finished we took in the CATs and sat down and talked about them.

Practical constraints limit the extent to which this can occur, though.

Five teachers reported an increasing communication problem due to financial cutbacks and new staffing formulas:

We have 18 staff here overall involved in maths, and I would estimate that there are five who are full time maths. ... There are 6 teachers that have got one class and that doesn't represent the building of strength. It also creates unique problems when it comes to running a maths faculty meeting because they are not the only group which has a meeting at that time. So you never see certain people ... and that makes communication very difficult.

### Conclusions

The most important finding from this work is that many teachers are convinced that their classroom practice has changed, and has changed for the better. To our surprise, it was a common view that the most beneficial changes made in response to the introduction of the VCE had occurred not at years 11 and 12, but in the junior years 7 through 10. Teachers attributed this to the shorter school year at year 12, and the pressure to cover the curriculum. Perhaps innovation is easier for teachers to embrace when you are further removed from the pressures of high stakes assessment.

The value of talking with teachers once the innovations had become

routine, was that some sense of how stable these changes were could be gained. There were certainly strong hints in the teachers' comments that due to the increased workload these changes were creating, and also due to the significant changes the present state government had made in relation to staffing levels, a climate of "lip service" to the innovations was emerging, at least in some schools. While this is an important point in itself, as it could mean that the innovations are ultimately not going to have the long term impact that was hoped, and there was also the negative impact this trend was having on teacher morale.

There were of course teachers who had never been interested in change,

and who had steered as traditional a course as possible through the innovations. While they had been forced to go along with the changes they were highly critical of the philosophy behind them and would only be satisfied if there was a return to the traditional approach to teaching and assessing mathematics. Another way that these teachers had coped was to opt out of teaching senior mathematics altogether. Yet there was also evidence that at least some of the teachers who had opted out were beginning to adopt alternate approaches in the middle school. For these teachers, the responsibility of continuing to teach students at the senior level without feeling confident with the new assessment system seemed to be a major influence rather than a complete rejection of change. There was also some evidence of different teachers being encouraged to take senior mathematics

studies at least at year 11. So in some schools there had been movement of staff between the junior and senior levels. Greater communication between teachers since the implementation of the VCE was generally reported which might be expected from the introduction of major changes to the curriculum. There was not a lot of evidence though that teachers shared ideas about the changes they made in classroom practice. Instead, discussion was centred around marking of CAT 1 and the minimising of workload through sharing the setting of assignments and tests for similar classes. With the changes in staffing levels at some schools, communication between teachers had actually been reduced and this was making the running of a mathematics faculty very difficult.

A significant level of reluctance emerged concerning attendance at out of school inservices. The enormous academic workloads and extra-curricular activities certainly explained part of this general mood. But also poor experiences of general inservices had lead some senior teachers to organise tailored inservices for their school which they had found to be far more effective. Apart from the annual MAV conference, tailored inservices may well be the direction schools may opt for in the future.

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