Improving VCE Results

Introduction

It is possible to make small improvements in VCE results within a single year. Significant and sustainable gains however require a more substantive commitment across multiple year levels. If students are arriving in Year 10 mathematics with little or no formal algebraic skills they are not going to perform well in VCE Mathematics, particularly Mathematical Methods and Specialist Mathematics. The significant decline in students doing Specialist mathematics runs parallel with the decline in qualified mathematics teachers. Mathematics is the domain with the highest number of teachers working outside their area of expertise; “almost 50% of junior school mathematics classes and 32% of senior mathematics classes are taken by teachers with insufficient tertiary qualifications”. [McKenzie et al 2008]. Assigning these teachers to junior level mathematics classes is based on the assumption it will minimise the impact. The reality is that this deficiency cannot be hidden at any level!

Students in years 7 to 9 are more likely to miss out on some of the basic fundamentals, particularly in the area of algebra when teachers lack the pedagogical content knowledge. These students may be taught using methods known to create misconceptions such as “Fruit Salad Algebra”\(^1\). In some cases students are learning things that are simply not correct! Algebra lessons are often avoided by teachers with little or no mathematical background in favour of assignments involving statistics or measurement. While these areas of the curriculum are also very important NAPLAN data shows significant deficiencies in Algebra.

The individual classroom teacher can do wonders with their own students but this does not address the systemic problem with regards to teachers lacking appropriate pedagogical content knowledge. There are administratively and didactically strategies that can be deployed to improve mathematics outcomes. Most of us start by looking for great lessons and investigations and sharing these within the faculty. While all of these will help, **“academic feedback is more strongly and consistently related to achievement than any other teaching behaviour.”** [Bellon et al 1997. Pg 277] Feedback in this context is not simply saying “good job” or “great work”. Feedback must be an objective description of the student’s current performance and provide direction for future improvements. We need to help students focus on developmental goals, monitor their progress and target areas where they need to improve. The timing and immediacy of feedback is extremely important, “Anticipation of more rapid feedback improves performance”. [Kettle & Häubl 2010] Technology enables us to get information back to students within seconds of them completing a task.

The TI-Navigator™ system provides immediate assessment of student results. While students are initially interested in their overall grade, providing time to analyse and discuss each question using the data provided by the Navigator system encourages students to engage in academic discussions and reflection. It is easy to ‘hide the correct response’ so that students can explain their thinking and reasoning. Student responses can be used as a guide for the teacher to determine

---

the most appropriate course of action. Student reactions and responses to this type of assessment demonstrate their change in perception from test to diagnostic, from administrative to informative. This is a beautiful example of formative assessment and academic feedback. When the teacher uses this level of instruction to make learning more focused, students respond by addressing their weaknesses which in turn provides more immediate and significant gains.

The information provided in this document and the associated attachments represents a sample of the actions and resources used to increase student learning, engagement and ultimately VCE mathematics results.

**Years 7 - 8 Mathematics: Online Assessment**

There are numerous companies that provide on-line interactive mathematics environments that generate increased engagement and incorporate much greater assessment detail. There are many advantages to using such systems:

- Provide enormously rich student data with no corresponding increase in teacher work load! This data can be used by the classroom teacher to provide individual pathways for students and informative academic feedback to students and parents. Mathematics coordinators can also access the data and use it to guide school programs by analysing strengths and weaknesses.

- Most of these environments can be easily tailored to match the needs of students; differentiating student learning has never been this easy.

- On-line tools such as “Manga High” and “Mathletics” can be provided to each student for an entire year at a cost comparable to that of a take-away meal. Incorporating these costs in school fees is the simplest remunerative solution.

- Corrective feedback can be provided whether the student is working in the classroom or at home.

- While students are using these on-line environments teachers can conduct ‘student interviews’.

- Incorporating on-line material into work-guides using the point scoring system is a very effective method of encouraging students to complete tasks and reattempt when they are having difficulties.

**Years 7 - 10 Mathematics: Spreadsheet**

This spreadsheet provides assessment strategies that generate large amounts of student data. It is extremely easy to manage and share this data. A spreadsheet represents a time and cost efficient method of data management in addition to being highly customisable. A sample spreadsheet containing actual student data has been provided. (Student names have been changed)

---

2 Mathletics & Manga High – These organisations are mentioned as I have used both environments successfully with students.

3 Student Interviews: Refer to Years 7 – 10 Mathematics Work Guide

4 Point Scoring System: Refer to Years 7 – 10 Mathematics Work Guide
• **Summary Sheet:** Provides a summary of all topics. (Sample provided shows a single topic only: Pythagoras). This sheet is typical of a paper based record book that lacks the multidimensional opportunities afforded by the spreadsheet. Comments, portability and live data updates make the spreadsheet alternative a more powerful option.

• **Topic Sheet:** Break down of assessment items for each student. The scores for each item are related directly to the work-guides provided to students. Comments (insert comment) can be used to produce more detailed information if required. For example: “Was absent for 3 days during assignment” can add important detail. Data can be imported directly from the TI-Navigator software and most on-line providers such as Mathletics and Manga-High include features such as ‘export to spreadsheet’. Automated grade assignment and alignment with National Curriculum outcomes make report writing much quicker and provide a much greater level of accuracy and detail.

• **Communications Sheet:** Students have ‘interviews’ during each topic. These interviews are generally conducted during class time while other students are working either on-line, on their assignment or completing textbook exercises. Cross tutoring via help lists recorded on the board can help free teacher time to provide high quality feedback to individual students. Comments to students are recorded in this sheet so they can be monitored over time and shared with parents as necessary. Parent communications can also be monitored on this page. Using the filtering tool it is easy to bundle all communications with a single student (or group of students). This sheet makes report writing very efficient, accurate and focuses on academic feedback.

<table>
<thead>
<tr>
<th>Student</th>
<th>Reference</th>
<th>Topic</th>
<th>Date</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>Text</td>
<td>Pythagoras</td>
<td>15/12/2012</td>
<td>Working out for routine questions. Perfect. Difficulties with extension.</td>
</tr>
<tr>
<td>22</td>
<td>Math</td>
<td>Pythagoras</td>
<td>15/12/2012</td>
<td>Worksheet on surds incomplete and doesn’t recognise even numbers.</td>
</tr>
<tr>
<td>23</td>
<td>Book Work</td>
<td>Pythagoras</td>
<td>15/12/2012</td>
<td>Work set out perfectly, book extremely well organised, problem questions answered.</td>
</tr>
<tr>
<td>24</td>
<td>Book Work</td>
<td>Pythagoras</td>
<td>15/12/2012</td>
<td>Difficulty expressing a number as a product of its prime factors.</td>
</tr>
<tr>
<td>25</td>
<td>Book Work</td>
<td>Pythagoras</td>
<td>15/12/2012</td>
<td>Homework not complete. Questions for follow up not highlighted and not discussed.</td>
</tr>
<tr>
<td>26</td>
<td>Book Work</td>
<td>Pythagoras</td>
<td>15/12/2012</td>
<td>Book work set out perfectly. Didn’t complete all the exercises.</td>
</tr>
</tbody>
</table>

• **Parents Sheet:** Parent email details are collected and email addresses confirmed using a ‘generic’ email distribution. Parents are regularly informed of their child’s progress. These emails take less than 20 minutes to construct and deliver valuable information to parents with much greater frequency. Feedback from parents has been very positive creating a much stronger network between teacher, student and parent. Work guides are also distributed to parents in this way. This level of communication means parent teacher interviews can focus more on improvement strategies rather than conveying data... and there are no surprises waiting for parents which makes the evening far more productive. From a spreadsheet management perspective it is often easier to temporarily dump selected information on a single sheet rather than filtering through the large number of columns available. (“Email_One” sheet)

• **Data Sheet:** This is essentially an administrative sheet that makes formulas within the Excel workbook more efficient. Refined versions of this spreadsheet include the ability to graph class averages against individual student data.
Years 7 - 10 Mathematics: Work Guide

Students need regular feedback on how they are progressing. The work-guide provides a summary of the topic with information relating to how they will be assessed and what is required to obtain the various levels of achievement within the topic. Certificates are provided for students gaining a ‘Credit’ or higher. These certificates can be kept in the student’s record book and are also produced by a single mail-merge taking only a few moments to produce. Scores provided for each assessment item are explained in detail to students.

Example: Text book exercises = 10 points.
Organisation is assigned 3 pts. Students are required to maintain an index (can be work-guide pasted into book) including page references to exercises as applicable. Exercises need to be self corrected. When a student gets a question wrong or had difficulty with a question it should be highlighted and followed up in class. Work needs to be dated and kept neat. A combination of these characteristics form the mark and students must identify (as applicable) where they can improve on this score. Students do their own assessment (boxes) which is then verified by the teacher in the table and on the spreadsheet. The current version of the spreadsheet does not include separate spaces for the organisation and mathematical content.
Mathematical content is assigned 7 pts. This is not just about getting answers correct. This criterion relates to the number of questions attempted, appropriate use of mathematical notation, conventions and finally, the number of questions completed and marked as correct. This assessment tool has room for improvement and suggestions and comments are welcomed. Discussions with other teachers highlight possibilities to have questions grouped into different levels which would provide further feedback and detail with regard to student ability level.
Years 7 - 8 Curriculum

Most schools offer mixed ability classes at the junior secondary level. Students in the upper primary classes have often experienced a degree of ‘streaming’. There are many arguments for and against streaming, too many to enter into here. It is however extremely important that high achieving students continue to be challenged. Teachers that lack the pedagogical content knowledge may struggle to provide resources that will challenge student thinking and reasoning. Tasks provided by some of the experienced VCE mathematics staff should be incorporated into these classes. These tasks are ‘voluntary’, parents need to be informed of their existence and completion of these tasks requires a level of recognition and of course high quality feedback. Schools can use the completion of these tasks to help assess if a student is actually performing at a higher level. Judgements about student ability are often erroneous when teachers working outside their domain are not completely familiar with the scope and sequence of the mathematics curriculum. Judgements are often comparative rather than criteria referenced. Many discussions have taken place with teachers assessing junior and middle school students well beyond the expected level yet none of the nominated achievement standards have been covered. The work-guides and additional assessment items can provide a more substantive and consistent approach to reporting.

Consider for example students completing work in year 7 on the “Prime factorisation” of numbers. One of the tasks in the Texas Instruments Learning Centre relates to “Factors that Count”. This activity initially requires students to explore the prime factorisation of numbers but then leads onto index laws and generalisation to form a rule that determines the quantity of factors based on the prime factorisation of a number. This particular activity includes teacher notes and answers! Students operating at the expected level should be able to complete the first sections of the activity, later sections incorporate algebraic generalisation.

http://education.ti.com/aus-nz/learning
Year 9 Curriculum

There are many schools that offer accelerated programs in mathematics. This is referred to as ability grouping and is different than streaming. [Commonwealth of Australia, 2010 pg67]. These classes can be highly competitive and relatively productive for the students involved but detrimental to the remaining classes. Ability grouping and streaming effected “how they perceived themselves as learners of mathematics and their views on pursuing mathematical studies beyond year 10” [Zevenbergen 2003 & 2005]. Students in low streams of mathematics reported “very negative experiences in their mathematics classes including: frequent changes of teachers, non-mathematics teachers allocated to the classes, and low-level work that they found too easy.” [Boaler & Wiliam 2001]. Consider this from a purely statistical stand point: if only one class from a year level is accelerated and all other streams run a more simplistic curriculum; weighting alone will reduce the average result achieved by the student cohort therefore negatively impacting on overall VCE results. An alternative option is to provide an ‘elective’ study in mathematics that is open to all students. This was introduced at my school with remarkable success. Classes ran for one semester and focused on completing many of the higher level components of the achievement standards that were often omitted from regular courses. Students in this elective study were able to engage in the extension work in their regular classes if they had already completed the required work. Students were therefore receiving a differentiated curriculum with no additional work required by the classroom teacher!

This opportunity motivated and engaged students in these classes. Students wishing to study “Mathematics for Methods” in year 10 (refer below) are highly recommended to complete the elective study. Students that emerged through this program spiked the schools VCE mathematics results in a very positive way.5

Year 10 Curriculum

Students in year 10 are generally self aware of their mathematical ability and relative engagement with the subject. While many of these students have not yet determined their career path, they are unlikely to be tending toward Engineering if they do not enjoy mathematics. The range of student abilities at this level is also at a point where content really needs to be differentiated, rationalising the denominator using difference of perfect squares is unlikely to be relevant to a student struggling to plot points on the Cartesian plane. Subjects offered at this level may include:

- Work Skills / Year 11 Foundation: Designed for students that are not planning to study mathematics in year 12.
- Mathematics for General: Designed for students planning on doing General Mathematics in year 11 and Further Mathematics in year 12.
- Mathematics for Methods: Designed for students planning on doing Mathematical Methods and potentially Specialist Mathematics.

It is extremely important that parents and students are supplied with the appropriate information regarding this course selection. Students should not attempt to move up the ‘conceptual’ scale. Course counselling processes need to provide parents and students with recommendations, it is not our place to

5 Year 9 Elective Program: Unfortunately this program was discontinued because the school was unable to provide suitably qualified mathematics teachers for regular classes. The elective study was therefore deemed a luxury the school could not afford to accommodate.
destroy student aspirations, only to advise them of the level of difficulty expected and even supplementary references to help them prepare for such courses. At the conclusion of the year 10 courses there will still be students wishing to move up the conceptual scale. It is not the role of the school to block students from taking such paths, a doctor can provide advice and prescribe medication, but the patient still has the final decision about their course of action. (Putting aside issues of euthanasia) Schools need to have modules of work for students wishing to move from Year 10 Mathematics for General into Year 11 Mathematical Methods. These units need to be completed over the summer break.

**VCE Mathematics – Course Offerings**

There are a range of structures recommended for VCE level mathematics. The General Mathematics course is relatively flexible with regards to content. It is highly recommended that students considering Specialist Mathematics complete the General Mathematics course. This should be a completely different course than the one offered to Further Mathematics clients. Many schools do not have sufficient numbers to warrant running a dedicated ‘Specialist Mathematics’ version of the General Mathematics course. It is therefore appropriate to run General Mathematics for Methods and Specialist. There are numerous examples of overlap within these courses; a prime example is the use of matrices. While matrices are not specifically included in Specialist Mathematics, they represent a wonderful tool for working with vectors. Other opportunities include ‘rationalising the denominator’ and ‘realising the denominator’ (complex numbers), the procedures are the same and can be taught to the sub-groups within the class.

Students that attempt General Mathematics and Methods in year eleven can attempt almost any combination of mathematics subjects in year twelve:

- Further Mathematics (only)\(^6\)
- Mathematical Methods (only)
- Mathematical Methods + Further Mathematics
- Mathematical Methods + Specialist Mathematics

**VCE Mathematics & TI-Navigator**

The importance of immediate feedback has already been highlighted in this document. It is extremely powerful at the senior mathematics level. Students selecting Mathematical Methods have generally been at the ‘top of their class’ in mathematics. Most of them have received excellent scores in the past and are generally very confident. What these students don’t understand is that their ‘competition’ comes from a similar background. An interesting task to provide your students at the start of the year is following:

“Imagine it is December, the sun is on your face, it’s a beautiful day but your heart is pounding because you have just received your year 12 results. You find your mathematics result. You read it. You don’t fall to the ground in despair nor do you leap around with excitement. The mark you just read is about what you expected. It is commensurate with the effort that you put in during the year. Now... write that number down, with your name, and give it to me.”

---

\(^6\) **Further Mathematics**: While the content of the General for Methods course is different than General for Further, these students generally cope fine with the transition.
For the past 3 years I have required students to complete this task. Every year the class average of these student scores exceeded 40. This in no way reflects the average achieved by students at the school. These unrealistic expectations are very dangerous. High scores achieved by these students throughout their secondary mathematics classes, and often with minimal effort, create a dangerously unrealistic expectation of their ability and potential result. No one wants to asphyxiate their aspirations; however it is too dangerous and destructive to provide false illusions of their real and relative ability. It is too late at the end of the year for students to find out these scores are NOT currently indicative of their score. It is extremely important that students realise very early that they will need to work very hard to achieve such scores! For my students I produced a collection of resources used with the TI-Navigator system that proved to be highly motivating for the students rather than destroying. The material utilises past examinations, examiner’s feedback and the data generated from the TI-Navigator system.

An example of this assessment is provided below. The question information is sent to the student’s calculator via the wireless TI-Navigator system. As soon as students have responded the software marks the responses and produces a graphical analysis of the results. In the example provided below students clearly performed ‘above’ the expected level with more than half the class responding with the correct answer. The analysis also reveals that 4 students chose the same incorrect response. These students are questioned in relation to their logic. Using the software is it possible to conceal the correct answer therefore providing much more discussion as students anticipate the outcome. From a neurological perspective, this small level of suspense is likely to release dopamine in the brain increasing the likelihood the learning will be remembered.

The tangent at the point (1, 5) on the graph of the curve \( y = f(x) \) has equation \( y = 3 + 2x \).

The tangent at the point (3, 8) on the curve \( y = f(x - 2) + 3 \) has equation

A. \( y = 2x - 4 \)
B. \( y = x + 5 \)
C. \( y = -2x + 14 \)
D. \( y = 2x + 4 \)
E. \( y = 2x + 2 \)

Q5. The tangent at the point ...

The curve of \( y = f(x) \) has been translated 2 units to the right and 3 units up. The image of the point (1, 5) is (3, 8). Hence the gradient of \( y = f(x - 2) + 3 \) at the point (3, 8) will be 2. The equation of the tangent at (3, 8) is \( y = 2x + 2 \).
The successful response by students in this example is widely celebrated. Students are also questioned with regards to ‘what has lead to such a good understanding’. Student responses to this question can be very informative, particularly if they are able to cite specific activities completed in class that have lead to such a result. When this happens, the activity must be flagged to ensure its inclusion in subsequent years.

The next question has been asked many times with almost identical success rates. The class results instantly confirmed my class was performing slightly below the expected level demanding attention to this problem.

The examiner’s suggested solution was foreign to most of my year 12 students. A quick survey of the class revealed that none of the students had used Matrices in year 11 Methods. This is a faculty level issue requiring a curriculum audit to ensure courses reflect the study design. (Don’t rely solely on textbooks) Another feature of the TI-Navigator system is the ability to transfer documents and view student calculator screens either individually (presenter) or collectively (class screen capture). In this case students were sent a TI-Nspire document to help them see how matrices can be used to solve such problems.
To begin students use a slider to vary the value of K to obtain a visual representation of the problem and identify there are two cases where the lines appear the same. Student results are immediately collected by the teacher to ensure all students have numerical results for the answer based on the visual representation.

In the same document students explore how the equations relate to the matrices. Either by experimentation or ‘logic’ students determine the values of ‘a’ and ‘b’ that form the matrices and subsequent equation set.

Further into the same page on the document, students see the inverse matrix represented and can then draw conclusions based on their algebraic knowledge.

In this capacity Navigator was used to check class understanding on a particularly problem, provide feedback and then corrective content to solve the problem. Subsequent testing on this item revealed a significant improvement in student results for tackling these types of problems.

Note: Another interesting trend from the initial question data relates to the number of students that selected the same incorrect response. Student results amounted to simply reversing the positive and negative signs on each value.

Where better to finish than on another question where the state-wide results were around 80% or higher and my students were clearly guessing! (What gives it away?)

After completing many similar assessments, indicative grades for students becomes a very easy task since the Navigator system holds all the results it is easy to incorporate these outcomes with other data.