NSW Board of Studies
Stage 6 Mathematics Review Symposium
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Education:

- Years K to 12:
  Mortlake Primary School
  Ashfield Boys' High School
  1981 HSC, including 3 Unit Maths
- Bachelor of Arts, Diploma of Education (Mathematics)
  Macquarie University (1982 to 1985)
- Graduate Certificate in Education (Enrichment Mathematics)
  University of Canberra (2004 to 2005)

Employment:

- Mathematics Teacher
  Prairiewood High School (1986 to 1992)
- Mathematics and Computing Studies Teacher
  Marrickville High School (1992 to 1995)
- Head Teacher, Mathematics
  Concord High School (1996 to 1998)
- Mathematics Coordinator
  PLC Sydney (1999 to present)

Professional:

- Association of Independent Schools Mathematics Professional Development Committee (2000 to present, Convenor 2006)
- Member of MANSW since 1986

Academic Interests:

- Making mathematics meaningful, interesting and relevant to students of all ages and abilities.
- The professional development of mathematics teachers.
- Using technology to improve conceptual understanding.

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Introduction:

Firstly, I would very much like to thank the Board of Studies for the opportunity to participate in this event. I include this detailed written submission because I fear that 20 minutes will not be anywhere near enough to express all that I would like to say.

I bring to this symposium a range of experience, from Marrickville High School to PLC Sydney, teaching boys and girls of all abilities over a 21 year period. I have taught ALL the current Board of Studies mathematics courses and I have led a mathematics department in a comprehensive coeducational high school and in an independent girls' school. I humbly believe that the ideas presented here represent the views of many teachers, parents and students.

Secondly, I would like to say that I am very supportive of the new Board of Studies arrangements for Stage 5. Previously, we had the Advanced, Intermediate and Standard Courses. Three courses were never enough! There were always students who fell in the gaps between the courses (as well as those who were above Advanced and below Standard). There were many students who were capable of doing the Advanced topics, but could not do ALL the Advanced topics in the available time. They were therefore consigned to the much easier Intermediate Course, which made it virtually impossible to do the 2 Unit or Extension 1 Courses in Stage 6. Under the new arrangements, these students can do 5.1, 5.2 and the most useful bits of 5.3. This is a good thing!

My current school has 7 classes in Year 10. We are making practical and workable decisions about the depth and breadth of treatment, rather than merely trying to push the students over some arbitrary line that signals the end of the Advanced Course. We have made significant changes to the way we assess and report and are using the new Course Performance Descriptors as we construct each of our assessment tasks, rather than using them in hindsight at the end of Year 10.

It was unfortunate that the old Stage 5 had 3 courses and the new Stage 5 has 3 Pathways. In speaking to colleagues from other schools (who have not embraced the changes in the way that my school has), it would appear that many have just seen this as a change of name, rather than a change in philosophy.

In Stage 6, the most recent changes led to the number of mathematics courses in Year 12 changing from 5 to 4 (when two existing courses were replaced with General Mathematics. Again, 5 courses or 4 courses or 10 courses would not be enough to cater for the vast range of mathematical abilities of our students. I fear that if the new Stage 6 has 4 courses there will be the inevitable direct conversion from the old Stage 6 to the new.

Recommendation 1:
The Board must seriously reconsider the number of courses in Stage 6, the names of the courses and the relationships between the courses, so that they connect well with the current arrangements in Stage 5.

Background Information:

Other than the General Mathematics Course, which commenced in 2000, the Stage 6 Mathematics Courses have barely changed since the introduction of scientific calculators in the late 1970's. **During that time, many things that impact on the teaching of mathematics in schools and universities have changed significantly:**

A greater percentage of students are finishing Year 12. Students in general have become more outspoken and are more likely to question the material they are learning and the value of it. The question "What is the point of learning this?" is far more likely to be asked these days.

Educational research into learning styles and **brain research** have highlighted the different learning needs of students. It appears that traditional mathematics teaching caters for only a very small percentage of our students and that we as maths teachers (and syllabus writers) have an important role to play in making our subject as inclusive as possible.

The HSC courses in other subjects have undergone many changes and new courses have been introduced, some of which have become very popular. It is no longer compulsory to do a mathematics/science course for the HSC.

The percentage of students doing 4 units of mathematics fell, then rose in recent years. **The percentage doing 2 units** has been sliding. The **percentage doing a non-calculus based course or no maths** has risen considerably.

The creation of many additional places in selective high schools has lowered the ability of comprehensive high schools to offer the Extension courses.

On-going assessment for the HSC and a wider range in the nature of assessment tasks has meant that regular mathematics homework is often deemed less important than completing a take-home assessment task for another subject. "Will this be in the assessment task?" is another frequently asked question in classrooms. These, along with the **intense competition to gain entry into some university courses,** may be some of the reasons why the **tutoring industry is booming!.**

There are ever-increasing expectations from the Board of Studies that assessment and reporting are **outcomes-based** and **standards-referenced**. The change that this has brought about in the mathematics courses is tokenistic, mainly because the syllabuses and examinations were not reviewed as part of the "new HSC".

The shortage of mathematics teachers has worsened. In actual fact, there **ARE** enough trained mathematics teachers in Australia, but many of them have pursued other (higher paid) career options.

The introduction of HECS and university fees may have prompted students to choose university courses with definite career paths attached, such as law and medicine. Many students can't see value in studying mathematics beyond Year 12.

The universities have introduced a **variety of new degrees**, some of which are very attractive to students who may have chosen to study mathematics in previous years. In the last few years the universities have started "advertising" their maths-related courses, but it may be a case of "too little, too late". Universities have also dropped the notion of using **HSC courses as prerequisites**.

Technology has changed dramatically. Computer software, the internet and hand-held devices, if used appropriately, have the capacity to:

- Change the way we teach and learn mathematics, with more emphasis on understanding the underlying concepts and using them to solve real problems and less emphasis on mindlessly regurgitating algorithms
- Change the relative importance of some branches of mathematics
- Allow students and teachers equal access to high quality learning materials

My mathematical and teaching journey:

My father is a retired lithographic printer. His trade required him to be good at arithmetic. Mental and written calculations were a daily event. He instilled in his three sons (usually over the dinner table) the importance of speed and accuracy with numbers. From birth, he tortured us with the conversions between eighths and decimals. This treatment served us well as we progressed through school. We all decided to be mathematics teachers!

My father's trade, like so many others, has changed irrevocably, mostly due to new technologies. My trade has changed little in the last 20 years (especially in NSW) despite the vast amount of change that has happened in other KLAs and in mathematics education in other Australian states and overseas.

I was younger than my brothers and was the only one to be permitted to use a calculator in my HSC examinations. I did the 3 Unit Course (but only sat for a 3 Unit exam, not the 2 unit and 3 Unit). The Board made some very minor changes to the Stage 6 mathematics courses during my university years. They removed 3-dimensional coordinate geometry, translation of axes and introduced some "real life" financial applications (superannuation and loan repayments). Other than that little has changed, except for the quality of the printing in the text books! In 2006 I am still teaching the same material that I learnt as a student, with basically the same calculator.

I am currently the leader of the Mathematics Department in the secondary school of PLC Sydney, a K to 12 comprehensive girls' school in the inner-western Sydney suburb of Croydon. Unlike PLC Pymble and MLC Burwood, our students do not carry lap-tops, but make use of computer and graphics calculator technology when appropriate. We encourage our students to choose a harder rather than easier maths course and to pursue mathematics beyond school. In the current Year 12, there are 12 students doing 4 units of mathematics, 26 doing 3 units, 46 doing Mathematics (2 unit) only, 34 doing General Mathematics and 25 doing no mathematics at all. In recent years approximately 50% of our Year 12 students have scored UAI's over 90. This includes several students who did General Mathematics.

Over the years I have actively tried to improve the degree to which my students understand the concepts the mathematics they are learning, often by using a variety of new technologies in my lessons. These include graphics calculators, internet sites and computer software such as Excel, WinGeom and Geometer's Sketchpad.

There are many fine reasons for using technology in mathematics lessons and during high-stakes assessment:

- It gives teachers and students the ability to bring sophisticated mathematical concepts to life and therefore improve conceptual understanding.
- Static textbook snapshots can be made into dynamic and interactive scenes that can be viewed by students in class and at home.
- It allows concepts to be explained and understood more quickly and efficiently.
- It increases the likelihood that a student will notice or discover a relationship or make a connection.
- It induces classroom discussion, arouses students' curiosity and generates "what if" questions from students.
- It allows a series of complex yet tedious calculations to be repeated with a different set of numbers, easily and instantly.

I am fortunate to be working in a school that can afford this technology, but having worked elsewhere I am aware that this is impossible in many schools. Basically, if it is not a compulsory course component, many schools will decide that it is unaffordable or too difficult, while other schools reap the rewards. The inequity between schools will grow exponentially. Decisions about technology made by the Board in the past to prevent inequity and to allow schools the option of using technology are now causing greater inequity.

Recommendation 2:
The board should mandate (and frequently review) the use of technology during lessons, assessment tasks and examinations. Only in this way can inequity between schools and systems be reduced. Any decision to mandate technology must be made at least 2 full calendar years prior to implementation and be clearly publicised to all schools.

The current options in Stage 6 mathematics:

No Mathematics:

The Board does not publish the number of students doing no maths course for the HSC. In some schools this figure is very high. Having taught Year 11 and 12 in 4 different schools, in some cases to students who really had no interest whatsoever in the subject, I respect the right of the individual to opt out of mathematics at the end of Year 10.

However, I believe that in recent times a growing number of quite capable students are dropping mathematics before or during Years 11 and 12. This concerns me greatly. The removal by the Board of the breadth of study requirements may be a contributing factor, as may be the minimum of 10 units in Year 12 decision. I believe that the reluctance of the Board to review and update the courses has also contributed. In other KLAs, the new HSC courses look and sound more attractive than our outdated and stale calculus-based courses.

Recommendation 3:
The Board should investigate the percentage of students choosing not to do any mathematics for their HSC over the last five years and their mathematical ability, based on state-wide testing.

General Mathematics:

Prior to the introduction of General Mathematics, I taught Mathematics in Society and Mathematics in Practice many times. I watched the evolution of General Mathematics with great interest. I knew at the time that other states were implementing courses in which students were using graphics calculators. I had been to some workshops and was amazed at what these devices could do and the impact that might have on our courses. I could see great potential for the enhancement of the conceptual understanding of students. It seemed to me that the starting assumption of the General Mathematics syllabus writers was that all students would have them when they did the HSC and that the syllabus would reflect that. It did. Unfortunately it was later decided to make the HSC examination "calculator neutral", so most schools chose not to use the technology, claiming that it was unaffordable and non-essential. I immediately established a scheme at my school for buying and selling second-hand graphics calculators. I have taught the course four times, to students with their own graphics calculator. I am in no doubt that my students who learnt how to use it well had an enormous advantage. I have recently had an article about this published in the MANSW journal Reflections.

There are many students in NSW for whom General Mathematics is much too difficult. There are also many students who cope quite well with the Preliminary Course but then find the HSC Course significantly more difficult. The old Stage 5 Standard Course and the new Stage 5.1 Pathway are not adequate preparation for General Mathematics. For the vast majority of General Mathematics students, this is compounded by the fact that they don't have the technology that the syllabus writers expected they would have!

Recommendation 4:
Even though the General Mathematics Course is quite new, it must be reviewed with the other 3 courses. The level of difficulty of the course and the difference in difficulty between Preliminary and HSC need to be addressed. The use of technology needs to be mandated by the Board.

Mathematics (2 Unit):

I would argue that this course is much more difficult than the 2 unit courses in other subjects. Some will say that this course needs to be rigorous enough to allow the students to enter certain university courses that have mathematical components. However, many capable students doing this course feel a sense of frustration because they are trying to learn and understand many difficult concepts, but in order to succeed in this course they need to spend inordinate amounts of time memorising formulae and rote-learning algorithms, at the expense of studying their other subjects and therefore jeopardising their UAI.

Students are aware now that many of the skills they learn to do by hand can be done on a computer or with a calculator and they don't all subscribe to the "eat your vegetables" theory. That is, draw these graphs by hand because it is good for you!

Many students who DO manage to score good marks on this course have little or no conceptual understanding or appreciation of the underlying principles involved. Dedicated teachers feel ashamed and embarrassed by this. We do it so that they manage to jump through the HSC hoops. For the vast majority of students in this course, it is basically an exercise in preparing them for the HSC examination. The coaching college / private tuition industry is a booming multi-million dollar industry fuelled by unrealistic expectations!

Some students choose this course because they want to do a particular university course, but how much of this course do they really need when they get there? The universities have dropped almost all of their prerequisites and offer students bridging courses to bring them up to speed.

If one were to compare the 2004 HSC Examination for this course with the 1989 HSC Examination, one might conclude that this course had been re-written. The exam itself has become much too difficult for the vast majority of students sitting it, especially those who are not doing Extension 1. The mean raw HSC mark in the 1990s was almost always below 50%. It was probably lower than that in more recent times. Our 2 unit students are often very despondent and distressed when they leave their last-ever mathematics examination.

This level of difficulty is then reflected in school exams, which has been one of the major contributing factors for the movement of students out of this course. Some have been moving to General Mathematics. The more recent trend is for students in this course to drop maths completely at the end of Year 11, as they move from 12 units to the minimum of 10 for Year 12.

The examination was once a good test of the skills (algorithms) they had learnt in the 2 Unit course. In recent years there have been several instances in which the Extension 1 students had a significant advantage, because they were able to use Extension 1 techniques in the 2 unit exam.

Much of the course content is dated. The "real-life" applications are contrived and tokenistic, especially those relating to finance. (A 25 year loan with fixed interest: I'd like one of those please!). The physical applications conveniently ignore the effects of friction and air resistance.

There are many concepts in this course that seem to serve no real purpose for the students who are doing this course, but are merely there because students in the Extension courses need them. Locus, trigonometric identities and much of the quadratic function topic fit this description.

Recommendation 5:
There is a need for a 2 unit course in mathematics which adequately prepares students for further study in mathematics-related undergraduate courses or for those with aptitude for mathematics seeking something more challenging than General Mathematics. The current Mathematics (2 Unit) course does not appear to be currently meeting the needs of those students and must therefore be thoroughly reviewed and renewed. Current technology has a role to play in this.

Mathematics Extension 1

This is a challenging course, but students are aware of that and accept it on that premise. Problems from circle geometry, mathematical induction and harder curve sketching require time to ponder, experiment and investigate, but this exam is the most time pressured of all. Does it need to be 2 hours only?

Mathematics Extension 2

For many years the number of students doing this course was declining. After the "new HSC" was introduced there has been growth. In my opinion, this is purely related to external factors, rather than the course itself. There are fewer Extension courses available now. Also, Physics and Chemistry are more literacy based, so students with poor English language skills are dropping them at the end of Year 11 and taking Extension 2 Mathematics. There is also the UAI scaling, which is very favourable for Extension 2 students, even those on the 25th percentile.

The chief examiner (a university lecturer) at the MANSW HSC Examiners Day recently said: "I could not complete this exam in 3 hours!" What hope does the "average" student have? Mind you, they don't need to do very much of it to get a decent mark. Three good responses to eight of the questions will produce a high HSC mark. A student with poor English skills may be better off with 4 units of maths rather than 2 or 3 units of maths plus another subject from another KLA.

Recommendation 6:
The Extension courses must be retained, with students being able to complete 3 or 4 units of mathematics. The content of the courses needs some attention as does the role of technology, but the level of difficulty of the course should not be altered. The Extension 2 HSC Examination has become overly difficult in recent years and therefore needs to be addressed.

The marking of the HSC examinations:

Earlier this year I attended the HSC Mathematics Examiners' Day. Senior markers of each course describe the marking of various sections of the 2005 HSC Examinations. I was appalled at some of the decisions that were made by the marking teams, especially in the 2 unit course. In many cases, students who made significant progress towards the solution (and therefore the course outcome) were penalised heavily or awarded no marks at all, in some cases because they used incorrect notation. Then the judging is done and most students are no doubt given a very significant boost to get almost all of them over the magic 50% line.

What concerns me is that the teachers who go to days like this would return to their school and implement the same form of punitive and pedantic marking, in order to emulate what happens at HSC marking, but without the generous mapping that follows the judging. The message this sends to the students is that their maths teacher is basically mean and nasty, but the Board of Studies are the "good guys".

Recommendation 7:
When the new syllabuses are released and specimen HSC assessment tasks are published, specimen marking schemes and examples of marked scripts must also be included so that teachers in different schools are more consistent in their approach to marking student work.

Ideas/Suggestions for the new Stage 6

The role of technology in Stage 6 mathematics:

Some will argue that technology should not drive the mathematics syllabus. I believe that the Board cannot plan and write new syllabuses until a firm decision has been made about the role technology will play in the new courses, both in the classroom and in the examination room. This will involve a thorough investigation of what is being used in other states (and internationally) and also what is looming on the horizon.

Some will argue that technology should not be prescribed. Experience has shown that if the technology is not compulsory it will not be used by schools, either due to financial constraints or in the mistaken belief that it is not worthwhile.

If the decision is made to prescribe technology, it will be necessary to make it well known throughout the educational community, because:

- Schools and systems will need at least 2 years to budget and plan for it
- Teachers will need a significant amount of professional development
- Universities will need to consider the implications for their undergraduate courses

Similarly, if the Board decides NOT to allow technology in the HSC examinations, the reasons behind this decision will need to be clearly publicised (equally early in the review process).

There are many concepts in all our courses that could be addressed and assessed in a very different fashion if the available technology was compulsory. Some will argue that this will have a "watering down" or a "de-skilling" effect. Students are allowed to use current technology in the examinations of the mathematics courses in the International Baccalaureate. Those who teach and assess these courses claim that they are at least as rigorous as the current NSW Stage 6 mathematics courses, which were recently declared to be the best in Australia by the Masters Review.

My response is this:
If the syllabus, the lessons and the examination questions are well constructed then teachers, students and university academics will see that we value, perhaps above all else, the conceptual understanding on which most areas of mathematics is based. The current rigour of the Stage 6 syllabuses will not be compromised by the appropriate use of technology in the classroom and the examination room.

> **Recommendation 8:**
> **Decisions about technology need to be made as soon as possible. If the Board decides to allow more advanced technology in their HSC examinations, they should find many examples from other states and countries that will clearly show the wider public how the examination can shift from memorisation and regurgitation of algorithms to assessment of conceptual understanding and problem solving. These would need to be ready to be published as soon as the announcement is made.**

There is a wide array of technology available that can be used by a creative teacher to enhance the learning of mathematics. The range and capabilities of computer software currently available is incredible:

Geometer's Sketchpad / Cabri Geometry / Win Geom
WinPlot / Autograph / FX Graph / Graphic Calculus / Graphing Calculator
Excel
Tinkerplots/Fathom
Maple
Mathematica

There are also numerous web-sites that bring particular mathematical concepts to life. They show students that the static images in their textbook are just snapshots of a dynamic situation. When I show these things to students in my class I am amazed at the questions they ask, the comments they make, the sudden interest that they show and the discussions that follow.

I see evidence in my school and at conferences of teachers doing amazing things in their classrooms with this software. At MANSW and AIS conferences, sessions involving technology are always well attended. Technology is NOT a trivial gimmick taken up by some teachers to motivate their students. In almost all cases I have seen, the intention is to radically improve students' conceptual understanding. Technology has the potential to give a wider range of students deeper access to sophisticated mathematical concepts than ever before.

Recommendation 9:
The actual syllabus documents, viewable on-line, must contain numerous links to files, movies, web-sites and other demonstrations of mathematical principles that teachers and students can interact with and observe. Many teachers will generously donate these if the Board asks them to do so. This must be an integral part of the syllabus writing process.

At some stage in the near future, I hope that students who are well-versed in the appropriate use of good mathematical software and hardware will sit for a well designed HSC examination that will test conceptual understanding like never before. Unfortunately it will be at least 10 years before every student can do their Maths HSC Examination using a computer-like device (yet to be invented).

For the time being, there are some options that need to be considered in this review of Stage 6 mathematics in NSW. Students have been using graphics calculators in other states for about 10 years. The next generation of calculators (such as the CASIO Classpad) is upon us. These have the power to do algebraic manipulation using a Computer Algebra System (CAS). In Victoria, by 2009, every Year 12 student will be able to use a CAS calculator in the VCE examinations. (Even New Zealand has moved ahead of NSW in this direction!) I believe that hand-held technology such as this can bridge the gap until more powerful technology is widely available in all schools.

NSW is a large market for the calculator producers. The Board could make a decision about what it will allow in the exam room and ask the calculator companies to produce something new to comply. Organisations such as the Department of Education could buy the "NSW model" in the same way they bought Microsoft Office and computers for the "roll-out".

What needs to be removed from the courses?

Locus? Conics? Circle Geometry? Parametrics?

What should be introduced?

Matrices? Vectors? Logic? Iterative methods? Statistics? Topology? Number Theory? Modelling?
Will the introduction of new technology allow more topics to be covered?

These decisions must not be made lightly. Apart from the section below on statistics, I will refrain from entering this debate at the moment. Instead, I urge the Board to consider the following.

Our calculus courses are basically 40 years old now. This is not a time for "tinkering" with our current courses. They need a thorough overhaul! It is time to take everything out of the Stage 6 mathematics wardrobe and throw it all on the table. Then, the Board needs to decide on the structure of courses:

- How many courses?
- Overlapping or separate?
- For whom is each course intended?
- What are the post-school options from each course?

The arrangement of courses could (should!) be quite different to the current course structure.

Then, one-by-one, each item on the table needs to be subjected to the following interrogation:

- How does this piece of mathematics relate to the other pieces in the wardrobe?
- Is this piece of mathematics worth putting back in the wardrobe? If so, in which course(s) does it belong?
- Is there something else that would be better to have in the wardrobe?
- Will students going on to university find this topic useful? What for?
- Does anybody use this in the "real world"? If so, what do they do with it? (That information should be included in the syllabus.)
- Does the prescribed technology change the way this topic should be taught and assessed?
- What do we want students to be able to do by hand (without technology) and with the technology?

It may be possible to place some topics in more than one course, with the depth of treatment being different, in a similar fashion to the 7 to 10 syllabus.

The syllabus writers need to give very clear definitions of the depth of treatment that is required. The new K to 10 syllabus does this very well.

Recommendation 10:
All the current courses need to be completely dissolved and totally re-built, using a process like the one described above.

Should statistics be in the Stage 6 mathematics courses?

Many people think that statistics should be in all the Stage 6 mathematics courses, possibly because it is used in so many ways of the "real world". I agree.

Those who disagree will argue that **statistics is not mathematics**. I agree with this, but I think we as maths teachers are the only ones in the high school that can teach it to students, judging by the glazed look that fills the eyes of many teachers when we discuss HSC mapping, UAI scaling and statistical estimation of student results after illness/misadventure.

Some have suggested that statistics should be a stand alone HSC course. I don't imagine that this would be a viable proposition in many schools.

Some may argue that students in Years 11 and 12 can't understand the mathematics underlying statistical tests, so we therefore can't teach them how to use the statistical tests. This is like saying that you have to know how a car works to be able to drive one!

Statistics is not mathematics. It is acceptable to teach students what the tools are used for and how to use the tools without necessarily teaching them about how the tools were made and why they work.

The link with the universities

High school mathematics is related to tertiary study more than any other subject. However, in my experience most high school mathematics teachers know very little about how the mathematics they teach is used in university courses involving pure mathematics, applied mathematics, finance, sciences, technology and engineering. We assume that everything in our current 2/3/4 Unit courses is useful for something at university. Is that assumption still correct in 2006?

The universities will no doubt have much input during this review. This would be an ideal opportunity to gather information about what they do with the mathematics we teach and to somehow make that more widely known to teachers and students. This needs to be gathered from a variety of faculties in a variety of universities.

I believe that many students who love mathematics choose non-mathematical courses (law, medicine, commerce, etc.) because they have no idea what a mathematical career might look like. Every topic in the new Stage 6 syllabus documents should be riddled with links to web-sites, documents, personal accounts and video clips that clearly show what people in the "real world" do with the mathematics that the students are learning, so that when students ask the inevitable question "What is the point of this?", teachers will be able to point them in the right direction.

Questions such as the following need to be asked of the universities:

- Do students currently bring the required mathematical SKILLS and KNOWLEDGE to your courses?
- Do students currently bring the required mathematical CONCEPTUAL UNDERSTANDING to your courses?
- What mathematical skills do you want students to bring to your undergraduate courses?
- What mathematical concepts do they need to know in order to do your undergraduate courses?
- What other skills are valuable?
  - Communication skills
  - Problem solving skills
  - Ability to work in teams
  - Ability to use technology to solve mathematical problems

Recommendation 11:
The Board organises an extensive data gathering exercise in the universities to find out exactly what mathematical knowledge skills and understanding the various university faculties would like students to bring with them.

Consultation with teachers:

Whilst it is important to consult the universities, it must be remembered that those of us in schools teach students of all abilities. Only a small percentage of Year 12 students continue with mathematics at university. Extensive consultation with teachers throughout this process is absolutely essential. Experienced teachers are very astute judges of what their students can and cannot do. The implementation timeline must allow adequate time to plan and undertake professional development with technology, new content, programming etc.

Recommendation 12:
The Board establishes an email network of at least 50 experienced classroom teachers to act as a "sounding board" for ideas that are being proposed.

Suggested Stage 6 courses in a K to 12 continuum

Recommendation 13:
The Board should extend the K to 10 continuum into a K to 12 continuum, but it is essential that students are permitted to start Stage 6 mathematics before Year 11.

In the following model:

- All courses have the same prescribed technology.
- All courses up to 6.3 include statistics and some form of calculus
- All courses may be used in the UAI calculation

Mathematics Stage 6.1A (120 hours):
This course is a subset of 6.1B, not a different course. It is intended for students who completed 5.1 in Stage 5. This course can be counted towards the calculation of a UAI, but only for 50 marks. Schools have the flexibility to offer this course as:

- A 1 unit course for the duration of Years 11 and 12
- A 2 unit course for Year 11 only. Students sit the HSC in Term 4 of Year 11

This would hopefully solve the following problems with the current Stage 6 courses:

- Ever since the abolition of Mathematics in Practice, teachers have wanted a course for their less able students who want to do a maths course but can't cope with General Mathematics.
- Currently, many students are choosing a maths course in Year 11 for the sole purpose of achieving the required 12 units for Year 11. In many schools an entire line of the timetable is mathematics, so it is difficult for

students to do 12 units without maths in Year 11. Students receive no credit for this in their HSC or UAI, so they do minimal work, learn very little and unnecessarily inflate class sizes.

Mathematics Stage 6.1B (240hours):
This course is intended for students who completed 5.1 and some or all of 5.2/5.3 in Stage 5. This course can be counted towards the calculation of a UAI, for 100 marks. It would be a 2 unit course for the duration of Years 11 and 12. It includes all the content of 6.1A and additional content that is more difficult. It would be similar to the current General Mathematics Course, but would also include some form of calculus, but with a technology, graphing, problem solving focus, possibly similar to that used in the International Baccalaureate courses.

Mathematics Stage 6.2 (240 hours):
This course consists of 2 units in Year 11 and 2 units in Year 12. Some of the content would be common to the Stage 6.1 course, so that the HSC Examinations for 6.1 and 6.2 would have some common elements (30 marks perhaps?) similar to Advanced and Standard English. This might solve some of the inequity that currently exists with the calculation of the UAI, in which capable students who choose General Mathematics get an advantage over equally capable students who choose the harder Mathematics (2 Unit) Course.

The level of difficulty would be similar to the current Mathematics (2 unit) course, but the actual content would need to be modified in order to address the problems outlined earlier in this document. In the current Mathematics (2 Unit) course, almost every topic relies heavily on concepts met in Years 7 to 10. It might be worthwhile to have a few topics that they haven't met before (Introductory Logic, for example).

Mathematics Stage 6.2 (240 hours) + 6.3 (120 hours):
6.3 is a two year, one unit course that can be done concurrently with 6.2.
The level of difficulty would be similar to the current Extension 1 course, but would include the use of technology, in the similar fashion to the High Level International Baccalaureate courses. Schools should be given the option to offer 6.2 + 6.3 as:

- A 3 unit course for Years 11 and 12
- A 4 unit course in Year 11 then a 2 unit course in Year 12.
- A 2 unit course in Year 11 then a 4 unit course in Year 12

Mathematics Stage 6.2 (240 hours) + 6.3 (120 hours) + 6.4 (120 hours)
6.4 is a one year, one unit course that can be done concurrently with 6.3, or after 6.3.
The level of difficulty would be similar to the current Extension 2 course, but would include the use of technology, in the similar fashion to the High Level International Baccalaureate courses. Course materials, including notes, assignments, topic tests, etc. should be delivered online by the Board to assist schools with a very small number of candidates in this course.

Mathematics Stage 6.5 Distinction (120 hours):
For students who have accelerated in mathematics and therefore reached the end of the Stage 6.4 Pathway prior to the end of Year 11 (or earlier). This course could be a joint initiative between the Board of Studies, the universities and (possibly?) the Australian Mathematics Trust or AMSI. The course work and materials would be

delivered to students and schools online. Much of the work could be done independently by the student. Students who successfully complete this course would be granted exemption (and credit points?) for some first year undergraduate mathematics courses. This course would appear on the HSC Certificate. Students who do this course would count in their contribution either this or their 6.3 contribution, whichever is higher, as well as their 6.4 contribution.

A suggestion for the structure of the examinations:
If students are permitted to use prescribed technology in the HSC examinations, the Board may wish to consider a non-calculator section, in which important basic skills can be tested, before the students move to questions that address conceptual understanding, problem-solving skills and higher order thinking skills. If this is the case, the Board must be very clear about what the students need to be able to do without technology and should also consider providing students with a formulae sheet for every HSC examination.

Examinations to be sat	Time allowed	Marks on HSC (UAI)
6.1A only	1.5 hours	50 (50)
6.1A + 6.1B	2.5 hours	100 (100)
6.2 only	2.5 hours	100 (100)
6.2 + 6.3	2.5 hours + 2.5 hours	100 (100) + 50 (50)
6.3 + 6.4	2.5 hours + 2.5 hours	100 (100) + 100 (100)
6.5	2.5 hours	100 (100 for either this or 6.3, whichever is higher)

Conclusion:

This is not a time for "tinkering" with our existing courses. They all need a thorough inspection and overhaul. It is time to re-examine the Stage 6 syllabuses in the context of the possibilities that technology provides, without any compromise to the rigour of the current courses and with the aim of improving the conceptual understanding of our students.

I have great faith in the Board's officers and their processes to do this very difficult but important task of reviewing and renewing our Stage 6 mathematics courses. I have no doubt that the Board is "up to the task". I am willing to assist in any way I can. Once again I thank you for allowing me this opportunity.

Stuart Palmer
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