AMSI
AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE

Committee Secretary
Senate Employment, Workplace Relations and Education Committee
Department of the Senate
PO Box 6100
Parliament House
Canberra ACT 2600

RE: Inquiry into Academic standards of School Education

Dear Ms/Sir

The attached is submitted on behalf of AMSI and the International Centre of Excellence for Education in Mathematics (ICE-EM).

AMSI/ICE-EM would be pleased to meet with the Committee or to provide further written information on any of the issues raised. If the Committee travels to Melbourne, we would welcome a visit to the AMSI offices.

Yours sincerely

Jan Thomas

Jan Thomas
Executive Officer

On behalf of:
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Inquiry into the Academic Standards of School Education

Submission from:
The Australian Mathematical Sciences Institute (AMSI) and the International Centre of Excellence for Education in Mathematics (ICE-EM). ICE-EM is funded by the Australian Government through DEST and managed by AMSI.

AMSI is a national collaborative venture conducting a wide range of national activities across education, industry and research in the mathematical sciences. AMSI members include 27 universities, CSIRO, the Australian Bureau of Statistics and the Australian Mathematics Trust (see www.amsi.org.au/membership.php)

ICE-EM is carrying out educational programs ranging from school mathematics through to advanced postgraduate and industry courses. A key program, *ICE-EM Mathematics,* is the production of materials for schools linked to professional development for teachers. *ICE-EM Mathematics* is being developed in partnership with schools in all states and territories and covers Years 5-10. In Victoria and NSW, for example, this means the materials cover the final two years of primary and the first four years of secondary school.

This submission is concerned with mathematics. We believe that English and mathematics are the two cornerstones of education and that failure to achieve an appropriate level in either compromises students' capacity to participate in modern society, handicaps them in the study of almost every other school subject, and curtails their career and other opportunities. Thus we believe that it is essential that there be high standards, and high expectations, of students in these two crucial discipline areas and that priority should be given to ensuring that this happens.

Context
A number of concerns and comments specific to the terms of reference are addressed below. Standards in school mathematics cannot be discussed in isolation from the parlous situation of mathematical sciences in the universities. A thorough analysis of the consequences for the school system of the dire situation of mathematics and statistics in the universities is given in detail in the National Strategic Review of Mathematical Sciences Research in Australia (see www.review.ms.unimelb.edu.au).

At the time of this submission there has been no official response to the Review. Mathematical sciences departments in the universities are continuing to contract, many alarmingly so as they will have insufficient academic staff to teach a full three-year sequence of mathematics or statstics. This will continue to have a negative flow-on effect to schools and standards in schools for the following reasons:

- If the percentage of graduates in mathematics and statistics does not rise, the already serious shortage of secondary teachers will worsen.
- When the local university cannot offer a degree in mathematics, as is the case at Charles Darwin University for example, it discourages participation and high standards in mathematics at the local schools.
- There is an urgent need for mathematical sciences departments in the universities to work with education faculties to ensure that BEd and other education students take courses appropriate to the mathematical knowledge needed to teach at the level they will be teaching. However some universities with large numbers of education students have very few mathematics academics. Moreover, very few BEd primary degrees require that their students take sufficient courses in mathematics **content** during the four years. Most have weak or zero requirements for prior study of mathematics at Years 11 and 12.

- Senior secondary courses need input from mathematical scientists in universities to ensure that the courses meet the needs of students in a range of post-secondary courses, not just physical sciences and engineering. Modern environmental, biological and medical sciences are highly mathematical. Mathematical scientists are in demand in finance, risk management and security. Meantime, the level of participation in the more advanced Year 12 mathematics courses has dropped alarmingly and continues to fall.
- School mathematics more generally needs input from mathematical scientists to ensure that the curriculum reflects modern mathematics and statistics, and that there is coherence in the syllabus.

Some of the points above will be elaborated in addressing the terms of reference below.

Comments regarding the terms of reference

Whether school education prepares students adequately for further education, training and employment

There is international demand for mathematicians and statisticians and Australia must compete with other nations for the scarce mathematical skills it needs. It is important that as many local students as possible reach their mathematical potential. Highly achieving students of mathematics in Australian schools are very good. However there are not enough of them and there is a long tail of under-achievement and failure that is apparent well before the end of secondary education. International comparisons show that Australia could do better.

Australia participates in two international comparative tests: Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS). The style and content of these tests is very different.

The PISA study takes place every three years and covers English, science, mathematics and problem-solving. Students aged fifteen—for the majority this is the final year of compulsory schooling—sit a two-hour paper. The focus is on mathematics in every three cycles only. The last PISA that emphasised mathematics was in 2003. It will be 2012 before there is significant coverage of mathematics again. The focus is on life-skills rather than on concepts and skills and preparation for further study. Two items from PISA 2003 are appended (Appendix 1). Both have low-level mathematics expectations for 15 year-olds.

TIMSS is an extensive examination of mathematical knowledge and test items focus on mathematics concepts and skills. An example is attached (Appendix 2). For further examples see http://timss.bc.edu/PDF/T03_RELEASED_M8.pdf.

Australian PISA results are frequently quoted as indicating that Australian students are performing well mathematically compared with other nations. While it is commendable that Australian students have the knowledge and skills tested by PISA, it is not a valid assessment of the mathematics knowledge as only a fragment of the curriculum is tested. Some of the questions are effectively general aptitude tests rather than mathematical ones.

Year 8 TIMSS is the best guide as to how Australia is comparing internationally in mathematics. TIMSS concentrates on content. By Year 8 the curriculum and expectations of students are similar internationally, and differences in school starting ages have had time to even out. In addition, the Year 8 TIMSS tends to have more countries involved. Some countries, eg highly performing ones such as Singapore, participate in TIMSS but not in PISA.

Australian TIMSS results show that there is a much to be concerned about. Appendix 3 shows Australian Year 8 students compared with the average for students in the top five countries. Two points stand out:

1. The long tail of under-achievement indicates a high percentage of students who, early in their secondary education, are already likely not to have acquired the necessary background skills for intermediate and advanced level mathematics courses at Years 11 and 12.
2. The low percentage in the highest level compared with the leading countries. This bears out the view of senior teachers and academics that expectations of Australian students are mostly 'average' with insufficient challenge.

Clearly Australia can, and should, do better.

The extent to which each stage of schooling (early primary; middle schooling; senior secondary) equips students with the required knowledge and skills to progress successfully through to the next stage

The Year 8 data referred to above illustrates that, for many students, failure begins in primary schools. There are three contributing factors:

1. Benchmarking of Australian primary mathematics curriculum against Japan, Singapore, and California showed the international curriculum to be superior (see http://www.dest.gov.au/sectors/school_education/publications_resources/profiles/benchmarking_curricula.htm).
2. Many primary teachers lack the knowledge of mathematics to teach it well. Many education faculties make little or no attempt to ensure that trainee teachers are equipped with the mathematical knowledge they need before they graduate. This is documented fully in the AMSI/ICE-EM submission to the House of Representatives inquiry into teacher education (www.aph.gov.au/house/committee/evt/teachereduc/subs/sub058.pdf)
3. There is consistent anecdotal evidence that many primary schools do not devote sufficient time to the teaching of mathematics.

In the middle years, these problems are compounded:

1. Students in upper primary often have mathematically under-qualified teachers and a severe shortfall of secondary mathematics teachers means that students in the early years of secondary are often taught by teachers teaching out of field. The Deans of Science report on secondary mathematics teachers details the teacher supply problem (see www.acds.edu.au/Prep_Math_Teach_Aust.pdf).
2. The curriculum documents in primary Years 5-6/7 and secondary years 7/8-10 are not coherent. What should be a smooth transition is impeded by the lack of clarity in the documents and support materials.

The requirement that teachers keep micro-level records on each and every aspect, and on each and every student, takes valuable time away from teaching and makes teachers' lives unbearable. Across primary and the middle years, developments in P-10 curriculum in recent years have inflicted endless documents on teachers that are unclear, ambiguous and jargon-laden.

This is why ICE-EM is involved in an ambitious project to develop a set of materials covering upper primary to Year 10 that includes texts, professional development and supplementary materials. The textbooks clearly describe the mathematics to be taught and provide a smooth transition from primary into secondary schools.

The *ICE-EM Mathematics* project mentioned above provides teachers with the road map they need, especially if they are unsure of the content they are teaching. The project has potential to alleviate some of the problems concerning preparedness to undertake Years 11 and 12.

Year 12 Reports

ICE-EM has produced two reports concerning Year 12—one compares curriculum across the States (www.ice-em.org.au/year12maths.pdf) and the other documents the decline in the number of students taking advanced and intermediate level courses (www.ice-em.org.au/pdfs/Participation%20in%20Yr12%20MathsFinal.pdf).

The curriculum comparison concluded that pre-tertiary-entrance mathematics subjects across Australia vary enormously, with differences in philosophy, mathematical content and assessment so great that no two states' Year 12 mathematics subjects could be described as equivalent. This is at odds with the recent ACER study that compared Year 12 mathematics courses. This is because the ACER study appears to have looked at content in a rather superficial way and not in depth or at assessment. There appears to have been little consultation with mathematics staff involved in teaching first year university students who are well aware of the huge variations in standards across Australia. The authors of the ICE-EM curriculum study were not consulted by ACER during its inquiry.

The decline in the number of students taking advanced and intermediate level courses at Year 12 shows that many students are not equipped with the mathematics they need for further study. Some possible reasons include poor career advice and subject choice, universities dropping explicit pre-requisites, insufficient reward in university entry scores and schools not offering the more advanced subjects. The Deans of Science report cited above found that only 64% of secondary schools were offering the most advanced year 12 mathematics subject.

The extent to which schools provide students with the core knowledge and skills they need to participate in further education and training, and as members of the community.

As indicated above, too few students are achieving the knowledge and skills needed. Schools are not well-informed concerning mathematical sciences post-secondary education.

There has been a disconnection between school mathematics and mathematics and statistics as used in further study, research, business and industry. Many State curriculum bodies allow only token representation by academics on subject design committees. A feature of modern mathematical sciences is the interaction with other disciplines and the way new mathematics often comes from interaction within the sub-disciplines. Fundamental to this is a base that would traditionally be called 'pure' mathematics.

Teachers have had few opportunities to appreciate the role of 'pure' (a better word would be 'foundation') mathematics in applied, statistical and industry applications. The problem is compounded by the lack of interaction that discipline people have with education faculties and government education departments. Hence key people making decisions about mathematics in schools are disconnected from the real world of modern mathematics and statistics.

An example of this is the way in which curriculum authorities have promoted graphics calculator use. Graphics calculators can help some students visualise graphs and so forth. However, their use is confined to the artificially constrained school setting. They are not used in the workplace and seldom in tertiary education. The technology-free exam that has been introduced in Year 12 in Victoria, and is to be introduced into the IB, reinforces the fact that students must understand the concepts and have the basic skills needed to put them to good use, possibly by employing the serious computational tools provided by modern computers and software. School-assessed tasks that use computers in a way that they are used in the workforce and further study, rather than the misguided emphasis on graphics calculators, would better prepare students for both tertiary study and the workplace.

Careers advisors are misinformed about many aspects of modern mathematics and statistics and students are frequently counselled into inappropriate courses.

The standards of academic achievement expected of students qualifying for the senior secondary school certificate in each state and territory.
How such academic standards compare between states and territories and with those of other countries.

The best Australian courses, for example 4-Unit Mathematics in NSW and Specialist Mathematics in Victoria, compare well with those in, for example, the International Baccalaureate (IB). As noted above, there is a major problem with falling participation in advanced and intermediate courses and no consistency across States and Territories.

University administrators are one of the major sources of the problem. After all, if universities drop pre-requisites as they have done universally, and accept students into engineering who have not even studied calculus, who can blame schools for dropping advanced courses and permitting their students to hunt for TER points by taking soft options? Failure to reward students for taking more advanced subjects in TER calculations often exacerbates this.

Additional comments
Australian teachers already have some of the highest face-to-face teaching hours in developed nations. Current assessment and reporting requirements and curriculum documents are creating an added burden.

The Victorian Essential Learning Standards for mathematics are indicative of the kinds of documents that teachers are being asked to interpret and report against (see http://vels.vcaa.vic.edu.au/downloads/progressionpts/mathematics.pdf). A sample page is attached (Appendix 4).
The document is supplemented by assessment maps, but these are not in a downloadable format. The pages that complement Appendix 4 can be viewed at:
http://vels.vcaa.vic.edu.au/assessment/maps/maps_domain/maths/working/level3.html

We stress that these references are illustrative of a bigger, national problem and that the Victorian documents are samples of what is happening generally across the States and Territories. For example, there has been turmoil in Western Australia over outcomes based education and assessment. Teachers need clear road maps and clearer, unambiguous reporting regimes.

Concluding Comment
Academic standards depend on more than school curriculum. They require well-qualified teachers and strong university mathematical sciences departments in the universities.

ICE-EM Mathematics sets a benchmark for what should be achievable for many more young Australians in the critical upper primary and early secondary years. The work ICE-EM is doing is a model for the future and an opportunity for renewal.

Many more Australian students could be achieving higher standards in mathematics. The solutions are not simple but the work undertaken by AMSI/ICE-EM demonstrates that clear, contemporary mathematical standards can be developed when teachers and discipline people work together. This kind of collaboration needs to be followed at Federal and State levels, not just in mathematics, but also in other areas of the school curriculum.

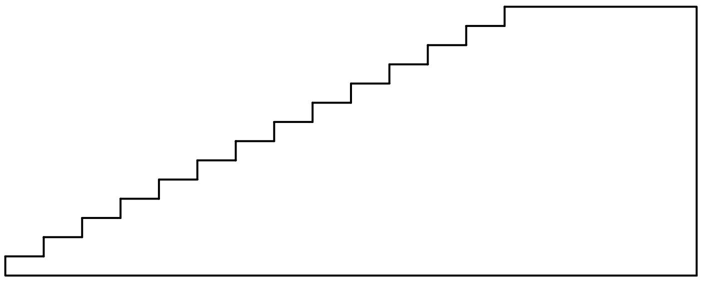
Copies of the AMSI/ICE-EM publications mentioned can be made available to the Committee. A report on the IB mathematics courses is being finalised. Copies of the Strategic Review are also available.

STAIRCASE

Question 1: STAIRCASE

M547Q01

The diagram below illustrates a staircase with 14 steps and a total height of 252 cm:



What is the height of each of the 14 steps?

Height: .... cm.

STAIRCASE SCORING 1

Full Credit

Code 1: 18.

No Credit

Code 0: Other responses.

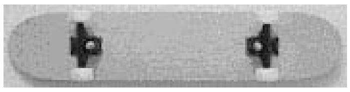
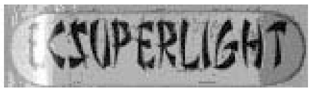
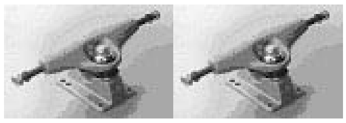
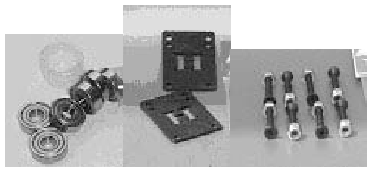
Code 9: Missing.

SKATEBOARD

Eric is a great skateboard fan. He visits a shop named SKATERS to check some prices.

At this shop you can buy a complete board. Or you can buy a deck, a set of 4 wheels, a set of 2 trucks and a set of hardware, and assemble your own board.

The prices for the shop's products are:

Product	Price in zeds	
Complete skateboard	82 or 84	
Deck	40, 60 or 65	
One set of 4 Wheels	14 or 36	
One set of 2 Trucks	16	
One set of hardware (bearings, rubber pads, bolts and nuts)	10 or 20	

Question 1: SKATEBOARD

M520Q01a

M520Q01b

Eric wants to assemble his own skateboard. What is the minimum price and the maximum price in this shop for self-assembled skateboards?

(a) Minimum price: .... zeds.

(b) Maximum price: .... zeds.

SKATEBOARD SCORING 1

Full Credit

Code 21: Both the minimum (80) and the maximum (137) correct.

Partial Credit

Code 11: Only the minimum (80) correct.

Code 12: Only the maximum (137) correct.

No Credit

Code 00: Other responses.

Code 99: Missing.

Question 2: SKATEBOARD

M520Q02

The shop offers three different decks, two different sets of wheels and two different sets of hardware. There is only one choice for a set of trucks.

How many different skateboards can Eric construct?

A 6
B 8
C 10
D 12

SKATEBOARD SCORING 2

Full Credit

Code 1: D. 12.

No Credit

Code 0: Other responses.

Code 9: Missing.

Question 3: SKATEBOARD

M520Q03

Eric has 120 zeds to spend and wants to buy the most expensive skateboard he can afford.

How much money can Eric afford to spend on each of the 4 parts? Put your answer in the table below.

Part	**Amount (zeds)**
Deck	
Wheels	
Trucks	
Hardware	

SKATEBOARD SCORING 3

Full Credit

Code 1: 65 zeds on a deck, 14 on wheels, 16 on trucks and 20 on hardware.

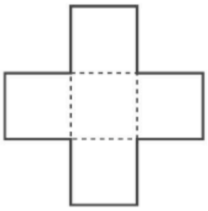
No Credit

Code 0: Other responses.

Code 9: Missing.

Appendix 2 – Sample item from Year 8 TIMSS

The figure consists of 5 squares of equal area. The area of the whole figure is 245 cm^2.



A. Find the area of one square.

Answer: _______________ cm^2

B. Find the length of one side of one square.

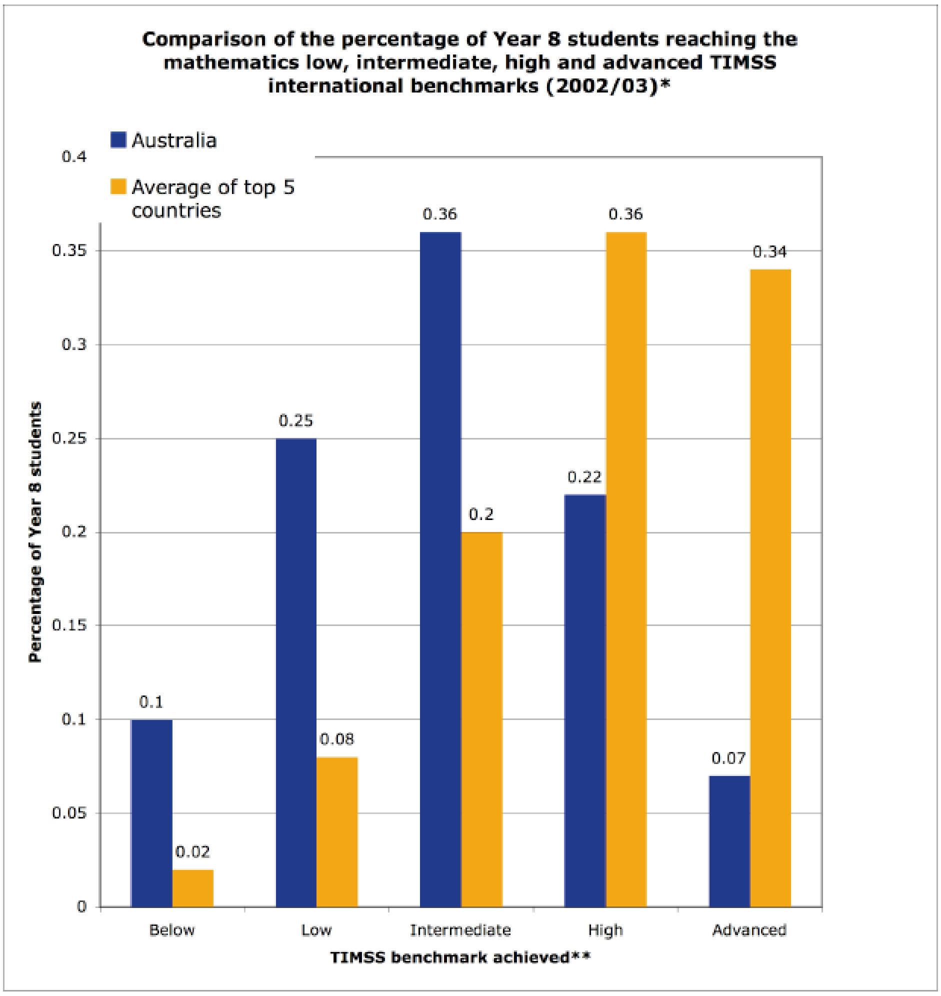
Answer: _______________ cm

C. Find the perimeter of the whole figure in centimeters.

Answer: _______________ cm

M022227

Appendix 3 – TIMSS Data



The TIMSS benchmarks for student achievement are defined as follows.

- **Below** – students have not met minimum level of basic mathematical knowledge
- **Low** – students have some basic mathematical knowledge
- **Intermediate** – students can apply basic mathematical knowledge in straightforward situations
- **High** – students can apply their understanding and knowledge in a wide variety of relatively complex situations
- **Advanced** – students can organise information, make generalisations, solve non-routine problems, and draw and justify conclusions from data.

Appendix 4

Victorian Essential Learning Standards

Standards and progression points

Progression Point 3.25	Progression Point 3.5	Progression Point 3.75
At 3.25, the work of a student progressing towards the standard at Level 4 demonstrates, for example:	*At 3.5, the work of a student progressing towards the standard at Level 4 demonstrates, for example:*	*At 3.75, the work of a student progressing towards the standard at Level 4 demonstrates, for example:*
• use of trial and error to find a missing number in a number sentence; for example, 4 × ? + 6 = 22 • use of language to describe change in everyday items or attributes whose value varies over time	• consistent and correct use of conventions for order of operations	• recognition that a given number pattern can be represented by an apparently unrelated equation and recurrence relation; for example, 5, 9, 13 … represented by 'multiply position in the pattern (first, second, third ...) by 4 and add 1' and 'start with 5 then repeatedly add 4 to the previous term' • understanding of zero and its characteristic of not having a multiplicative inverse, and the consequences of attempting division by zero
Working mathematically	**Working mathematically**	**Working mathematically**
• consideration of problems with a similar mathematical structure as a problem solving strategy • use of familiar problems to focus on strategies to help in solving an unfamiliar problem • search for counter-examples in an attempt to disprove a conjecture • location of data sources, including use of the world wide web • collection of mathematical data using technology; for example, using data logging	• application of mathematics to model and solve simple practical problems; for example, the construction of a pair of stilts • efficient communication when using mathematical language, symbols and representations • appreciation of the history of mathematics in development of geometry and number concepts • development and testing of conjectures with the aid of a calculator; for example, divisibility tests • incorporation of text, data, images and graphs using technology, to report the results of an investigation	• knowledge of interpretation of maps, graphs and models • understanding of patterns through the use of systematic strategies such as calculating first differences • application of a set of questions linked to an area of investigation • knowledge of appropriate historical information