

The assessment methods used in senior mathematics, chemistry and physics in Queensland schools

Report No. 25
Education and Innovation Committee
October 2013



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Acknowledgements

The committee thanks those who briefed the committee, made submissions, gave evidence and participated in its inquiry.

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Terms of reference

The Queensland Legislative Assembly referred the following terms of reference to its Education and Innovation Committee on 14 February 2013:

1. That the Education and Innovation Committee inquire into and report on the assessment methods used in Senior Mathematics, Chemistry and Physics in Queensland schools.
2. That, in undertaking this inquiry, the committee should consider the following issues:
 - Ensuring assessment processes are supported by teachers
 - Student participation levels
 - The ability of assessment processes to support valid and reliable judgments of student outcomes.
3. Further, that the committee take public submissions and consult with key stakeholders and relevant subject matter experts.
4. The committee is to report to the Legislative Assembly by 16 August 2013.

On Tuesday, 6 August 2013 the Legislative Assembly amended the reporting date to Monday 14 October, 2013.

Chair's foreword

On behalf of the Education and Innovation Committee of the 54th Parliament of Queensland (the committee) I am pleased to present the committee's report number 25: Inquiry into the assessment methods used in senior mathematics, chemistry and physics in Queensland schools.

The committee has consulted widely and gathered evidence from teachers, students, schools, peak and representative bodies, academics and bureaucrats in three Australian states during the course of this inquiry. I would like to acknowledge and thank all of those who have informed the committee, whether through written submissions, oral submissions, or participation in forums and meetings. The information you have provided has been invaluable to developing our understanding of this complex area, and of some of its philosophical underpinnings.

We are particularly appreciative of those who prepared very detailed and informative submissions to us, recognising that we are not technical experts; and to those who gave of their time to share their expertise and experience, despite having no vested interest in the inquiry at all. I refer particularly to teachers and officials from other jurisdictions, and to those who have retired from teaching or academia, or who have completed or are completing their senior studies.

The committee was struck by the level of passion and commitment to good educational outcomes that was expressed throughout the inquiry process.

The terms of reference led us to appreciate the complexity of assessment methods. After some time, we began to see that perhaps one of the best ways for us to add value to the questions that exist around assessment methods used in senior mathematics, chemistry and physics, was to 'unpack' some of those questions. We also began to see that some of the apparently opposing viewpoints being put to us were not necessarily opposing, or even mutually exclusive. The arguments had not been clearly defined. Sometimes, views about assessment processes were more fundamentally concerned by the subject's syllabus and its equal emphasis on three criteria. This is not surprising given the fundamental link between assessment, teaching and learning.

It seems to the committee that there is a need to more clearly define and explain the issues. As representatives of the community with no entrenched position on these questions, we hope we have brought a level of objectivity to the discussion and even simplified it somewhat from what initially appeared to be a very complex, convoluted set of issues.

The committee has made recommendations for the House to consider. Committee members believe they will, if implemented, simplify assessment processes, reduce workload and consequent stress levels for students and teachers, and promote valid and reliable assessments of students' achievements, without losing the benefits of school-based, standards-based assessment that have been gained over the past thirty years.

I wish to thank the members of the committee for their detailed consideration of the issues covered by the inquiry. I also thank staff of the committee's secretariat, and those who assisted them, for their support and assistance throughout the inquiry process.

I commend the report to the House.

A handwritten signature in black ink, reading "Rosemary Menkens .". The signature is fluid and cursive, with a large loop at the end.

Rosemary Menkens MP
Chair

October 2013

Executive summary

1. Introduction

The Education and Innovation Committee was asked by the Queensland Parliament on 14 February 2013 to inquire into and report on the assessment methods used in senior mathematics, chemistry and physics in Queensland schools. The terms of reference encompass the portfolio responsibilities of the Minister for Education, Training and Employment, administered by the Queensland Studies Authority, a statutory body of the Queensland Government. The assessment methods are implemented in all Queensland schools offering mathematics, chemistry and physics at the senior level.

The committee received 288 written submissions to the inquiry, the majority from teachers. The submissions indicated that there were significant concerns with the current assessment methods used. However it quickly became evident that assessment cannot be readily separated from teaching and learning because what is assessed, and how it is assessed, determines what is taught and learnt, and how it is taught and learnt.

While the terms of reference relate to senior mathematics, chemistry and physics, many of the issues raised relate to senior assessment generally, or to mathematics and science education generally.

Strong and passionate views were expressed to the committee. A parliamentary committee, with government and non-government members who represent the community, can offer an objective viewpoint. The committee has aimed to disentangle the issues and make recommendations to simplify assessment methods and ensure that they are valid and reliable, in the context of school-based assessment and a standards-based assessment system.

2. Key concepts

The committee's research indicates that there is a global awareness of the importance of mathematics and science education, and a perception certainly in western countries, that there are insufficient people with strong skills in these areas to ensure continued economic growth. Accordingly, there is a strong push for strategies to increase the number of people who have these skills.

Assessment in Queensland is a key part of the learning process, with teachers and students using it to reflect on and inform their teaching and learning over the course of study. Given the high stakes nature of senior assessment, what is taught and learnt is heavily influenced by what is assessed.

The assessment criteria in senior mathematics, chemistry and physics reflect both of what are known as 'lower order' skills, such as learning the core content and process knowledge relating to a subject; and 'higher order' skills, which are about analysis and synthesis, application and communication of that knowledge. Concerns have been expressed that assessment methods at present mean the teaching and learning effort focusses too heavily on higher order skills, at the expense of the more fundamental lower order skills.

The committee has heard that assessment methods need to be 'fit for purpose' if they are to be valid and reliable. They need to measure what they purport to measure (validity) and to do so consistently (reliability). As well, assessment methods might need to be different

depending on what it is they are aiming to measure: university capacity, especially in relation to other potential students; or achievement of a specified standard in relation to the criteria.

Moderation is undertaken in Queensland and all other jurisdictions, to ensure comparability of between school assessments. It is particularly important to moderate school-based components of assessment, where assessment tasks are set and assessed by individual teachers. Queensland uses a system of social moderation, using panels of trained teachers who review samples of work from all schools. Most other Australian jurisdictions use a form of statistical moderation, with a common task in the form of an externally set exam providing comparability between the assessments done at the school level.

3. Senior assessment in Queensland

Queensland's senior school program is a two year program over Year 11 and Year 12. Directed by the syllabus document for each subject, teachers design work, teaching and assessment programs which teach and assess the concepts outlined in the syllabus document. Students are assessed against specific criteria, and the standards of achievement awarded are based on the student demonstrating specified attributes in their assessment tasks. Standards are assessed qualitatively, with no numeric representation provided for in the syllabus documentation.

Students who are unable to access certain subjects at their school, or for adult students not enrolled at a Queensland secondary school (but participating in a program at an adult learning centre), have the option of sitting an externally set exam in Queensland. The Queensland Studies Authority (QSA) administers external exams in 22 subjects. However this is to be phased out, other than for languages, over the next three years.

Queensland's system is different to those of New South Wales and Victoria, both of which were emphasised to the committee as useful models for Queensland to adopt. Both models use numeric marking against standards, allowing achievement on assessment tasks to be added to achieve an overall assessment for a subject. Performance on a state wide external exam contributes at least half of the student's overall score. The external exam operates to moderate the school-based component of the score.

4. The issues

The perceived problems attributed to current approaches to assessment of senior mathematics, chemistry and physics in Queensland schools are:

- A decline in mathematics, chemistry and physics enrolments¹
- A decline in mathematics, chemistry and physics performance by Queensland students²
- Excess workloads for teachers and students, for no demonstrable benefit³
- Inability of teachers, students and parents to understand the standards as written⁴

¹ See for example, Submissions 105, 224 and 271

² See for example, Submission 30

³ See for example, Submissions 162, 215 and 227

⁴ See for example, Submissions 14, 84 and 184

- Assessment methods are inappropriate for assessment of ‘the basics’, and in fact mean they do not get taught or learnt⁵
- Use of assessment tasks that require English literacy for communication disadvantages some student population groups.⁶

There were a number of apparently opposing views about aspects of Queensland’s assessment system and their appropriateness for senior level mathematics, chemistry and physics, including:

- **School-based and external assessment** – and their respective validity and reliability
- **Assessment tasks** – extended investigations are seen to be too long and onerous, even while their use as a learning tool and for assessment may have been supported; and the style of presentation required (ie a written report format) is alleged to be biased against certain student groups (eg boys, those with limited literacy skills)
- **Number of assessment tasks** (ie continuous assessment) – is seen to be inappropriate, unnecessary and stressful
- **Numerical marking and standards-based assessment** – a very strong concern raised in submissions related to a perception that teachers are not allowed to use numeric marking. Using subjective descriptors is seen to be inappropriate for maths and science subjects, onerous for teachers, and leading to invalid, unreliable results.

The committee was required to consider whether assessment processes are supported by teachers. The QSA argued that teachers do support assessment processes, as evidenced by their participation on review panels, feedback in the annual survey and attendance levels at workshops. Of the 288 submissions received by the committee, a large number were from individual teachers who raised concerns about aspects of the assessment process. Some submitters oppose the entire system. Broad support was indicated by key representative bodies, which represent a significant number of teachers or schools in Queensland. Some of these bodies expressed support for the system, while identifying areas for improvement.

5. Student participation: the data

Diverse views were presented to the committee about the impact of senior assessment methods on participation in mathematics, chemistry and physics. The committee examined QSA data over a 10-year period and concluded that participation levels have in fact decreased, as they have all over Australia and internationally, however there was no suggestion that this is because of senior assessment methods. Mathematics C was found to be an anomaly, being the only subject to have a relatively consistent participation rate over the decade, the only subject to experience an increase in its completion rate and the only subject that does not have an increasing drop-out rate.

There have been decreases in many other ‘traditional’ subjects with the increase in offerings at senior level over the past decade, and this is not unique to Queensland.

⁵ See for example, Submissions 117, 200, 277

⁶ See for example, Submissions 21, 88 and 186

Research has shown that key influences on participation in these subjects include learning experiences and achievement in early years, socioeconomic background, university prerequisites and student perceptions about what post-school options specific subjects may lead to.

Some participants suggested that male participation in the sciences was decreasing. QSA data was analysed and the committee concluded that enrolments in physics, chemistry and mathematics B decreased over the decade for both males and females, as a proportion of the population. The proportion of enrolments in mathematics A and C remained fairly steady over this time, increasing slightly for mathematics A. The data does not indicate that male participation is decreasing at a disproportionate rate to females. In fact, if there is any reason for concern it is the ongoing and significant difference between the number of males and females studying the sciences and advanced mathematics, in favour of males.

6. Performance

Some inquiry participants expressed concern about the performance of Queensland students in senior mathematics, chemistry and physics, and suggested that this may be related to the assessment methods used. Under the current system, student performance in senior mathematics, chemistry and physics cannot be compared with students in other Australian states due to the different curriculums, assessment methods and reporting language and formats used. Due to this, the committee examined the performance data available for earlier years to see whether any major differences were evident.

This data indicated that overall, Queensland students' performance is generally not as strong as most other Australian jurisdictions and that this relatively poorer performance starts as early as Year 3 (when NAPLAN testing commences). However, Queensland student performance has recently shown signs of improvement. The committee noted the importance of participation in early childhood education and teacher quality in improving student performance. The committee concluded that differences in performance on tests such as Trends in International Mathematics and Science Study (TIMSS), Program for International Student Assessment (PISA) and National Assessment Program – Literacy and Numeracy (NAPLAN) cannot readily be linked to Queensland's assessment systems at senior or any other level.

7. School-based assessment

The committee sees the benefits of school-based assessment. There is great benefit in schools being able to tailor teaching to make learning relevant to their students, and teachers are well placed to assess the work of their students. The varied nature of the assessment tasks that can be set at a school level provide an opportunity for all students to demonstrate their achievements; and it ensures that assessment informs teaching and learning. Particularly in the science subjects, which are intrinsically about 'doing', it is important that students have the ability to demonstrate that they can 'do'. The fact that assessment also drives teaching and learning does represent a risk in terms of ensuring that assessment is 'fit for the purpose' of assessing all elements of the curriculum, including the core knowledge and processes relevant to these subjects. It is important that assessment methods ensure they are adequately taught and learnt. The committee believes a balance between school-based assessment and a common external element of assessment will achieve that aim.

8. Standards-based assessment

Many submitters raised concerns about the level of detail, and the nature of the detail, contained in the syllabus documents for the subjects in question. The committee heard criticisms that the description of standards is vague, subjective and unclear and many examples were provided. There is a concern that when combined with an entirely school-based assessment process, the level of subjectivity that is necessary to assess students' work using the current standards is too high for assessments to be valid.

However, some teachers found the standards descriptors very helpful in supporting them to explain to students what they needed to do to achieve higher standards, rather than simply telling them they needed to 'get more questions right'.

The committee agrees that there is a need for greater clarity in the syllabus documents in respect of the standards. It is vital to ensure teachers, who set and assess assessment tasks, and students, who complete them, can understand what they are aiming to achieve. The committee also questions whether there is a need for more precise standards descriptors in mathematics, chemistry and physics than for humanities subjects.

9. Assessment tasks

The main concern expressed about specific assessment tasks related to extended assessment tasks: extended experimental investigations, extended response tasks, and extended modelling tasks. Inquiry based learning is generally seen as important in these subjects, particularly chemistry and physics. However, as they are currently mandated, they are seen to detract from the ability of teachers and students to teach and learn the range of content that the syllabus says they should learn. They involve significant effort, yet cover only a small component of the syllabus content. There were suggestions that they should not contribute as heavily as they do now (ie. equally, given all criteria are equally important) to a student's overall achievement, and should be less onerous for both teachers and students.

There were also suggestions that they discriminate against males and against people with poor literacy skills; that an assessing teacher cannot be certain that the work is a student's own work; and the time and effort involved is causing severe distress for students and teachers. The committee makes a number of recommendations in respect of these assessment tasks.

10. The marking regime

Teachers reported difficulty with the marking regime as prescribed in the syllabus for each of these subjects. To some extent, the difficulty relates to the standards as currently described in the syllabus, but it also relates to the requirement to assess 'how many' (a quantitative assessment) of a qualitative mark a student had received, in order to determine an overall qualitative assessment of achievement. In essence, they felt they were required to add up letters. This issue relates very strongly to the perceived ban on numeric marking.

The committee agrees that the regime is complicated. Its recommendations in respect of numeric marking could reduce that complexity.

11. Numeric marking

This issue attracted the strongest and most consistent comment of any aspect of the inquiry. Almost all teachers who submitted to the inquiry, including the Queensland Teachers' Union, felt that numeric marking was very appropriate for the subjects in question and strongly rejected the perceived 'ban' on using marks. There is evidently confusion amongst teachers as to whether numeric marks can be used at any point of the marking process: whether for marking individual tasks, such as tests, or for determining an overall assessment. There is some ambiguity evident in the official position on this. The committee can see no reason why numeric marking cannot be used within a standards-based assessment system, as occurs in New South Wales and Victoria.

Numeric marking at the task level, combined with a clearer description of standards and a corresponding numeric scale for each standard, would greatly support teachers to undertake assessment.

Numeric marking would also support weighting of various tasks and components of tasks, which could direct teaching and learning to ensure that all elements of the syllabus are adequately and consistently covered.

12. Moderation

School assessments in Queensland senior subjects are moderated by a panel of experienced, trained teachers. Samples of work from every school are reviewed by panels, at the district and state levels, through discussion of the attributes of each work sample, and reaching agreement on the appropriate achievement level to be awarded. The QSA advises that there is a high degree of agreement by panels with school-based assessments, and with each other.

However some teachers have expressed concerns to the committee that the panel process is not ensuring valid assessments, because there is such a high degree of subjectivity in both the assessment and moderation process. This seems to be largely attributed to the perceived lack of detail and direction in the syllabus, in terms of the standards and criteria.

The committee recognises the value of school-based assessment for enhancing assessment for learning. It also acknowledges that participating on review panels enhances teacher quality, offering professional development which is key to good outcomes for students.

However, it seems that some of the strengths of the social moderation system – in particular its strong focus on people and on their expertise and commitment – might also be its weakness. The misunderstandings expressed about how social moderation works (i.e. through debate and discussion) are of concern; and reports that people feel intimidated and pressured is a direct function of the model being dependent on human interaction.

The committee questions the ability of review panels to adequately moderate assessments between schools in the absence of a common assessment task, and in the context of the level of detail about the standards provided by the syllabus. It particularly notes the potential for these factors to impact on the validity of panel moderated assessments. However, it does note the value of panels developing and reviewing common assessment tasks, and moderating them as a means of professional development in conducting assessment.

13. Cost implications

While this is beyond the scope of the committee's terms of reference, the costs and benefits of different assessment and moderation models will be relevant to the way forward.

The committee has considered some research associated with different assessment and moderation models, and presents a summary of that research.

14. Support for schools and teachers

It seems very likely that a substantial number of teachers of senior mathematics, chemistry and physics are teaching without formal qualifications in those disciplines. The recommendations made throughout this report are intended to ensure greater support is given to schools and teachers as they teach and assess senior level mathematics, chemistry and physics in Queensland.

15. Teacher qualifications

It is understood that there is a shortage of teachers with specialist qualifications in mathematics and science, nationally. The committee is aware that the government has strategies in place to attempt to redress this situation. The Queensland Auditor-General will shortly table a report of a performance audit relating to the supply of specialist teachers in Queensland, and the committee looks forward to reviewing that report.

The lack of teachers who have qualifications in mathematics and science is one rationale for a need for greater support for teachers who are teaching these subjects, often out of field.

16. Developing the evidence base

A striking aspect of this inquiry was the strength of opinion about assessment methods used in senior mathematics, chemistry and physics in Queensland schools – and the commensurate lack of empirical evidence.

The committee makes a recommendation for further research into comparative performance of senior students in Australian jurisdictions.

Recommendations

Recommendation 1: 81

The committee recommends that schools should retain the ability to determine the timing and nature of summative assessment tasks, with the syllabus specifying an upper limit on the number of extended assignment tasks; and a reduced contribution by inquiry-based tasks to a student's overall achievement grade (see also Recommendation 9).

Recommendation 2: 81

The committee recommends that an external exam count for 50% of a student's overall achievement mark in senior mathematics, chemistry and physics to:

- a) ensure an appropriate focus on content knowledge which, of the three criteria for each subject, is the one most readily testable by an exam task (and what is tested, gets taught)
- b) ensure an element of commonality in respect of content knowledge around the state, which makes comparing student scores more meaningful for employers and universities
- c) promote confidence in the validity of all of a student's final mark for a subject by increasing the likelihood of consistent assessment practices against a common task.

Recommendation 3: 81

The committee recommends that the syllabus documentation specify the goals of senior mathematics, chemistry and physics courses, in terms of post-school directions; and explicitly advise how the courses will achieve those.

Recommendation 4: 82

The committee recommends that the subject-based external exam for mathematics, chemistry and physics be used to scale school-based assessments, in recognition of the fact that exams provide a valid assessment of a student having 'the basic' content and procedural knowledge in the subject area and that the criteria relating to this knowledge should be a primary determinant of the student's achievement level in these subjects.

Recommendation 5: 87

The committee recommends that research be undertaken into whether there are differential impacts of standards-based assessment for humanities and mathematical and scientific subjects.

Recommendation 6: 91

The committee recommends the syllabus documentation be provided with more detail about standards of achievement against each criteria, to support teachers in their task of assessing students' standards of achievement against each criteria.

Recommendation 7: 109

The committee recommends that the syllabus prescribe that inquiry-based assessment tasks such as extended modelling, extended experimental investigations and extended research tasks, be completed in class time under teacher supervision, and that it specify a maximum number of hours that can be spent on these tasks.

Recommendation 8: 109

That inquiry-based assessment tasks be mandated at no more than one in each of year 11 and 12 (with schools free to use a maximum of two)

Recommendation 9: 110

That inquiry-based assessment tasks contribute to a defined proportion of a student's overall mark for that subject (a minimum of 12.5% and a maximum of 25%)

Recommendation 10: 110

That inquiry-based assessment tasks can be presented in a range of formats, including oral presentations, visual presentations as well as in a written report format.

Recommendation 11: 110

The committee recommends that a 'catalogue' of common inquiry-based assessment tasks, developed by trained specialist teachers and with associated task-specific assessment guides be developed to support teachers. The national curriculum may provide an opportunity for sharing of resources and experiences on a national scale, with support from industry and academia.

Recommendation 12: 110

That students be routinely questioned on aspects of their inquiry-based assessment task as part of the assessment process.

Recommendation 13: 125

The committee recommends that in the context of standards-based assessment, numerical marking be strongly promoted in maths, chemistry and physics alongside more specifically defined syllabus documents (see Recommendation 6) that include mark ranges to equate to each of the five standards of achievement for each criteria, to:

- a) increase clarity for students and teachers as to why particular standards of achievement are awarded
- b) ensure an appropriate focus is placed on content knowledge along with the higher order skills (numerical marks readily allowing weighting)
- c) reduce workload for teachers
- d) enable employers and universities and importantly, students themselves to readily see what content a student knows and does not know.

Recommendation 14: 131

The committee recommends that a (reduced) mechanism to enable teachers to set and review school-based assessment tasks should continue to operate for senior mathematics, chemistry and physics, but that this mechanism not be used to moderate school-based assessments.

Recommendation 15: 138

The committee recommends the QSA provide more direction to schools and teachers in respect of requirements for school-based assessment tasks, both in the syllabus documents and through training.

Recommendation 16: 142

The committee recommends the government undertake research to establish benchmarks and, at an appropriate time, evaluate performance progress in Queensland and compare Queensland performance in senior mathematics, chemistry and physics (and all senior subjects) with the performance of senior students in other Australian jurisdictions and internationally.

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Glossary

ACACA	Australasian Curriculum, Assessment and Certification Authorities
ACARA	Australian Curriculum, Assessment and Reporting Authority
ACER	Australian Council for Educational Research
AIG	Australian Industry Group
ATAR	Australian Tertiary Admissions Rank
DETE	Department of Education, Training and Employment
EEI	Extended Experimental Investigation
ERT	Extended Response Task
HSC	Higher School Certificate
IB	International Baccalaureate
IBO	International Baccalaureate Organisation
OECD	Organisation for Economic Cooperation and Development
OP	Overall Position
NAPLAN	National Assessment Program – Literacy and Numeracy
PISA	Program for International Student Assessment
QCAR	Queensland Curriculum, Assessment and Reporting
QCS test	Queensland Core Skills test
QSA	Queensland Studies Authority
QTAC	Queensland Tertiary Admissions Centre Incorporated
SEP	Senior Education Profile
STEM subjects	Science, technology, engineering and mathematics subjects
TE Score	Tertiary Entrance Score
TEPA	Tertiary Entrance Procedures Authority
The committee	Education and Innovation Committee
The department	Department of Education, Training and Employment
TIMSS	Trends in International Mathematics and Science Study
UNESCO	United Nations Educational, Scientific and Cultural Organization
VCAA	Victorian Curriculum and Assessment Authority
VCAL	Victorian Certificate of Applied Learning
VCE	Victorian Certificate of Education

PART ONE

1 Introduction

1.1 Inquiry process

1.1.1 Parliamentary inquiry purpose and process

The purpose of a Parliamentary committee is to inquire into and report on specific matters referred to it by the Parliament, or under the *Parliament of Queensland Act 2001*. Members of the committee are generally not experts in the field of inquiry, rather, it is their job to collect evidence, analyse and synthesise it and make recommendations back to the Parliament in response to the terms of reference.

Evidence is collected in a number of different ways, and these can and do vary depending on the nature of the inquiry and what the committee decides is appropriate. The committee invites evidence from experts, interested individuals and organisations; conducts literature reviews to gather relevant and current objective information; conducts site visits where this would add valuable information and brings all of this information together into a report and makes recommendations back to the Parliament.

In respect of assessment systems, the following quote suggests what a Parliamentary inquiry has to offer:

...there is no universal best technical practice that could be adopted. Instead, the choices made in devising assessment systems inevitably reflect the values and priorities of the broader social context in which they are made (Cresswell, 1996; Broadfoot, 1996).⁷

As Parliamentarians are representatives of the broader community, they are well placed to reflect those values and priorities. This is in contrast to a review or inquiry undertaken by technical experts.

1.1.2 Inquiry process

The Parliament of Queensland referred this inquiry to its Education and Innovation Committee on 14 February 2013. A reporting date of 16 August 2013 was originally set; however, this was extended to 14 October 2013 by the Legislative Assembly.

Government response

Under the Parliament of Queensland Act 2001, the responsible Minister is required to respond to the recommendations made by the committee within three months of the report being tabled in Parliament.

Public briefings

The committee invited and received briefings on 6 and 7 March 2013 at Parliament House, Brisbane, to inform its approach to the inquiry.

⁷ IBO, 2004, p4

The committee requested briefings from the Department of Education, Training and Employment, Independent Schools Queensland, Queensland Catholic Education Commission, Professor Peter Ridd and the Queensland Studies Authority.

A further public briefing from the Queensland Studies Authority was requested, and provided on 20 March 2013.

Public submission process

A total of 288 submissions were received from a wide range of stakeholders, interest groups, organisations and individuals. The committee agreed to requests from some submitters to withhold their names from publication, given the nature of the relationship between some of those submitters and the government, as their employer.

Public hearings

The committee conducted public hearings on 22 May and 5 June 2013 at Parliament House, Brisbane and on 10 July 2013 at Novotel Twin Waters Resort, Sunshine Coast, to inform its approach to the inquiry.

Expert advisory forum

The committee invited participants to an ‘expert advisory’ forum on 1 May 2013, to obtain evidence-based advice about the validity and reliability of assessment methods used in senior maths, chemistry and physics in Queensland schools. The majority of the 15 participants were academics and researchers from universities. The Australian Council for Educational Research (ACER) and the QSA were also represented. The list of participants and agenda are included at Appendix C.

The forum was not aimed at hearing submissions. It was an opportunity, within the time available, for the experts and the committee to have a dialogue about the issues and different perspectives on those issues, and to hear what the research evidence says. For practical reasons, the first part of the forum was not open to the public.

Presentations were developed during the program capturing the group’s views of specific issues and the evidence relating to those issues, including areas of divergent views. A proof transcript of the presentations by participants and group discussion session is available on the committee’s webpage at www.parliament.qld.gov.au/eic. This part of the forum was broadcast live via the Parliament’s website.

Study tour

The committee travelled to New South Wales and Victoria from 28-30 August 2013, and met with the Australian Curriculum Assessment and Reporting Authority (ACARA), the Board of Studies New South Wales, the Victorian Curriculum and Assessment Authority and teachers of mathematics, chemistry and physics in both of these states.

Private meeting with students

The committee met with some members of the YMCA Queensland Youth Parliament on 1 October 2013 and obtained their views as recent students about their experience with the assessment methods and processes used for studying senior mathematics, chemistry and physics.

Literature review

A search for relevant literature such as journal articles and other published reports was completed as part of the inquiry process. A bibliography is at Appendix F.

1.2 Scope

The terms of reference for the inquiry were fairly broad. While the focus was clearly on senior mathematics, chemistry and physics, many ‘assessment methods’ and ‘assessment processes’ relevant to those subjects also extended to senior assessment generally. Certainly, the committee isolated key assessment methods and processes that were specific to mathematics, chemistry and physics such as the use of written assignment-type tasks in subjects that some see as being fundamentally about numeric formulae. But other aspects of the terms of reference, such as validity and reliability, went to the heart of the senior assessment system more broadly because the methods and processes used to ensure validity and reliability apply to all subjects.

A large number of submissions were made to the committee in respect of this inquiry, the majority from teachers. The content of those submissions reflected that the scope for the inquiry was not entirely clear. Most submissions gave indications about assessment methods specifically in the context of these subjects (such as the use of extended assignment type tasks and whether numerical marks can be used in subjects focused on numeracy), and the levels of teacher support for those.

However there were also many submissions which focused on broader issues than the assessment methods used for mathematics, chemistry and physics, focusing more on:

- the syllabus for those subjects (is basic content and procedural knowledge sufficiently covered)
- the senior assessment system generally, including school-based assessment and moderation panels
- concerns about the Queensland Studies Authority
- concerns about teaching methods (direct instruction and inquiry-based learning).

The committee was asked to consider the validity and reliability of current assessment processes for mathematics, chemistry and physics.

There were concerns raised about the validity of extended assignment tasks with a ‘literary’ focus in mathematics and science subjects, and about the potential for cheating or unfair advantage impacting on their validity.

To take a broader view though, and bring the whole senior moderation process into scope, the moderation process is immediately relevant to the validity of any assessment. The number of submissions which touched on moderation indicate that to be the case.

The Queensland Government has recently announced an independent ‘Review of Senior Assessment and Reporting and Tertiary Entrance’ which addresses the broader issues raised during the committee’s inquiry.

With respect to the Queensland system of senior secondary school assessment and reporting, the review will consider:

- comparability across schools of student standards of achievement in the same subject, including review and moderation processes
- the appropriateness, validity and reliability of various types of assessment instruments used for senior secondary school subjects
- the adequacy of the current exit levels of achievement
- the form and content of reports to students and parents, including the Senior Education Profile, and
- implications of the Australian Curriculum for the Queensland model.

The committee's terms of reference require it to consider the validity of current assessment methods. It cannot do so without including consideration of the moderation system, because moderation of school-based assessment is a key means of ensuring the validity of that assessment. Consequently this report will make recommendations that may impinge on the considerations of the government's inquiry. This is not considered problematic. The two inquiries have different approaches: a parliamentary inquiry is not undertaken by content matter experts, but rather considers evidence presented to it by stakeholders, from published research, and submitted directly by experts. The government's inquiry is being undertaken by those with technical expertise. The reports of each will come from different perspectives.

Given the deep inter-relationship between many aspects of the assessment system, and the strong feelings about these that were expressed during this inquiry, perhaps one of the most useful things the committee can do is objectively 'unpack' some of those issues.

1.3 Policy context

1.3.1 Roles and responsibilities

The Queensland senior education system consists of various interacting entities and elements including government, non-government, State and Commonwealth bodies, roles and responsibilities. The system includes schools (generally classified as either state, catholic or independent), representative bodies, authorities, teachers, students and related policies, guidelines and regulations.

States and territory governments have the primary responsibility for the delivery of school education⁸:

*Each state government manages the school system within their state. This means that they provide funds and regulation for their schools. Both public schools and private schools exist in each state. The curriculum taught in each state or school may vary but the learning areas are the same in all.*⁹

⁸ <http://deewr.gov.au/school-education>

⁹ www.immi.gov.au/living-in-australia/settle-in-australia/everyday-life/education/whatis.htm

The Department of Education, Training and Employment (DETE) provides education for all Queensland state schools and sets higher level policies and procedures for all Queensland schools. Independent and Catholic schools, and indeed individual state schools, will also have policies at the school level governing the school's operations.

The Queensland Studies Authority (QSA), established on 1 July 2002, is a statutory body of the Queensland Government. It develops and provides syllabuses, guidelines, assessment, reporting, testing, accreditation and certification services for Queensland schools.¹⁰

Its (former) Chief Executive Officer, Mrs Patrea Walton, described the QSA as "...a partnership of teachers, principals, public servants and a wide range of education stakeholders including parent, tertiary and industry representatives who, through a variety of committees, perform its legislative functions."¹¹ These functions:

*...are defined in an act of parliament, the Education (Queensland Studies Authority) Act 2002. The act also prescribes the membership of the authority—a 20-person representative board with members appointed from teacher, parent, union and higher education groups as well as the state Catholic and independent sectors all contributing to a balanced perspective on curriculum and assessment. Providing advice to this board are the many representative committees that focus on various aspects of the curriculum, assessment, moderation and certification processes.*¹²

The QSA provides a range of educational services to Queensland schools and the community, including:

- developing, approving, accrediting and revising syllabuses
- providing educational services and resources to assist schools and teachers, including on how to administer assessment
- determining procedures and implementing quality assurance for senior school-based assessment
- designing, administering and marking the Queensland Core Skills Test and administering the senior external examination
- issuing certificates of achievement, and certified copies of certificates, such as the Senior Certificate and the Queensland Certificate of Education
- developing tertiary entrance procedures, issuing tertiary statements and providing information to the public about tertiary entrance procedures and requirements
- conducting and commissioning research and undertaking policy analyses in areas such as syllabus development and evaluation, assessment, testing and certification.¹³

Each Australian state has a body equivalent to the QSA.

¹⁰ www.qsa.qld.edu.au/about.html

¹¹ Hansard, 7 March 2013, Mrs Patrea Walton, p2

¹² Ibid

¹³ www.qsa.qld.edu.au/603.html

The national body for the chief executives of the bodies identified above is the Australasian Curriculum, Assessment and Certification Authorities (ACACA).¹⁴ ACACA:

*... exists to promote curriculum, assessment and certification in schooling functions within the framework of the Commonwealth of Australia and its States and Territories. The authorities represented through ACACA have a wealth of experience and expertise in 'high stakes' assessment and certification: securing and maintaining quality, credibility and integrity in an area of high pressure and demanding community expectations. ACACA provides advice on curriculum, assessment and certification matters, including matters of national concern.*¹⁵

ACARA is the independent authority responsible for the development of a national curriculum, a national assessment program and a national data collection and reporting program that supports 21st century learning for Australian students.¹⁶ Its work “...is carried out in collaboration with a wide range of stakeholders, including teachers, principals, governments, state and territory education authorities, professional education associations, community groups and the general public.”¹⁷

ACARA is responsible for collecting, managing, analysing, evaluating and reporting information about educational outcomes.¹⁸

Queensland schools are currently teaching:

- the Australian Curriculum for English, Mathematics, Science and History in Prep to Year 10
- the Queensland curriculum for the remaining areas of the curriculum in Prep to Year 10
- the Queensland Senior schooling curriculum for Years 11 & 12.¹⁹

Education Ministers from all states and territories have committed to developing and implementing the Australian Curriculum, which (when fully implemented) will set out the knowledge, understanding and skills needed for life and work in the 21st century, and establish common standards and high expectations of achievement across the nation.²⁰ ACARA develops the Australian Curriculum with input from educators in each state.²¹

The Australian Curriculum will gradually replace the Queensland curriculum.²²

At the time of writing this report, it was uncertain whether there will be any changes to the role of ACARA, or to the Australian Curriculum as a result of there being a new Australian government.

¹⁴ <http://acaca.bos.nsw.edu.au/go/about-acaca/>

¹⁵ <http://acaca.bos.nsw.edu.au/go/about-acaca/>

¹⁶ www.acara.edu.au/default.asp

¹⁷ Ibid

¹⁸ Ibid

¹⁹ <http://education.qld.gov.au/curriculum/>

²⁰ Ibid

²¹ Ibid

²² Ibid

The P-12 curriculum, assessment and reporting framework specifies the current requirements for Queensland state schools in delivering the curriculum from Prep to Year 12. The framework is accompanied by a series of policy statements providing further detail.²³

In implementing the P-12 curriculum, assessment and reporting framework Queensland state schools:

- provide students with the required curriculum
- assess, monitor and capture student achievement
- set high expectations for each student and respond effectively to their current levels of achievement and differing rates of learning
- prepare students to exit schooling with the foundation for successful lifelong learning and participation in the community
- keep parents and students informed of the student's achievement throughout their schooling.²⁴

The National Assessment Program – Literacy and Numeracy (NAPLAN) is an annual assessment for students in Years 3, 5, 7 and 9, which has been an everyday part of the school calendar since 2008.²⁵ It tests the sorts of skills that are essential for every child to progress through school and life, such as reading, writing, spelling and numeracy.²⁶ It does not explicitly test the curriculum at this point. It does not test scientific literacy at this point. The assessments are undertaken nationwide, every year.²⁷ NAPLAN allows for the making of national comparisons up to Year 9 level.

The Queensland Tertiary Admissions Centre Incorporated (QTAC) provides and operates a centralised tertiary application system and publishes comprehensive information for prospective applicants: *QTAC seeks to excel as the expert facilitator of an equitable tertiary entrance system for the benefit of tertiary institutions and their prospective students.*²⁸ It currently receives and processes applications for admission to the majority of undergraduate courses offered by the publicly funded universities in Queensland.²⁹ The institutions that participate in QTAC have complete autonomy in determining their own admission requirements and principles of selection.³⁰ Once these are determined, QTAC's role is to ensure that the admission rules and related procedures are correctly administered on behalf of these institutions.³¹

For admission to tertiary courses in 2013, all states and territories of Australia produce overall measures of their students' 2012 achievements in a common index that allow for comparisons to be made across states and territories and across time.³² This overall measure

²³ Ibid

²⁴ Ibid

²⁵ www.nap.edu.au/naplan/naplan.html

²⁶ Ibid

²⁷ www.nap.edu.au/naplan/naplan.html

²⁸ www.qtac.edu.au/AboutQTAC/AboutQTAC.html

²⁹ Ibid

³⁰ Ibid

³¹ Ibid

³² www.qtac.edu.au/Applying-CurrentYr12/InterstateAdmissions.html

is known as the Australian Tertiary Admissions Rank (ATAR) in all states and territories other than Queensland.³³

Queensland provides, to the appropriate authorities, individual ranks calculated according to the ATAR for Queensland students formally applying for tertiary admission interstate.³⁴ However, within the state, students' achievements are reported as overall positions (OPs), with other criteria used if necessary for finer rankings.³⁵

1.3.2 History

Mrs Walton for the QSA, observes that:

*The assessment system we have in place in Queensland today has evolved over 40 years. ...the furore over external exams in year 12, particularly the physics exam in 1967 which was so difficult that about two-thirds of the candidates failed... ...prompted a string of inquiries and reports: the Bassett report, Radford report, Scott report—which was ROSBA—and finally in 1992 the Viviani report. The current system has evolved from these reports.*³⁶

From 1910 to 1972, the University of Queensland set public external examinations.³⁷ Prior to 1972, universities had a large influence on the senior assessment process, through the external exam. The beginnings of school-based assessment in Queensland secondary schools can be traced back to the discontent from students, teachers, parents and politicians regarding external examinations, particularly the senior physics examinations of 1966 and 1967.³⁸ It was becoming accepted that Year 12 was catering for students other than those who intended to study at university.³⁹ The 1968 Bassett Report concluded that senior external examinations did not adequately meet the needs of most post-secondary school students and that those who entered tertiary institutions as well as those who went on to employment would benefit from the introduction of a leaving certificate concurrent with the existing Senior Certificate.⁴⁰

On 18 July 1969, a committee chaired by Dr William Radford, Director of the Australian Council for Educational Research, was commissioned by the Minister for Education “to review the system of public examinations for Queensland secondary school students and make recommendations for the assessment of students’ achievements” (Clarke, 1987).⁴¹ The report of the Radford Committee was presented to the Minister for Education in May, 1970 and recommended the abolition of both Junior and Senior external examinations, to be

³³ Ibid

³⁴ Ibid

³⁵ Ibid

³⁶ Hansard, 7 March 2013, Mrs Patrea Walton, p2

³⁷ International Association of Educational Assessment Conference symposium paper – ref no. WC0023, *Moderation: Principles, Policy and Practice Presentation, Externally moderated school-based assessment in Queensland – How we know that it works*, Peter Jordan, acting Deputy Director, Student Achievement Division, Queensland Studies Authority and Jo MacDonald, acting Principal, Senior School, Varsity College and State Review Panel Chair, Geography p2

³⁸ Ibid

³⁹ QSA, 2012. *School based assessment: the Queensland System*. www.qsa.qld.edu.au/3CD5FE4B-6128-4B29-B5A6-E9F1A8F78DF2/FinalDownload/DownloadId-C48566B66C7C7ACDCE25272E9AD3BDA8/3CD5FE4B-6128-4B29-B5A6-E9F1A8F78DF2/downloads/approach/school-based_assess_qld_sys.pdf

⁴⁰ Ibid

⁴¹ Ibid

replaced by a system of internal assessment and moderation to achieve comparability between schools.⁴² The Radford Report was implemented from 1971 to 1979.⁴³

In 1976, the Board of Secondary School Studies set up a committee to investigate the findings of two independent reports published in the same year (the 'Campbell Report' and 'Schools Under Radford') which criticised the implementation of the Radford Report:

*The committee set up by the Board to investigate these findings was chaired by Professor Ted Scott, Dean of Education at James Cook University. Initially, Scott acknowledged that some of the early problems under Radford were gradually being attended to as teachers came to grips with internal assessment and moderation. However, a major change recommended by Scott in 1976 was a shift from norm-referenced assessment to a standards based approach to assessment and reporting. This meant that students would be assessed on standards that they achieved rather than how they compared with other students.*⁴⁴

The final report of the Scott Committee, 'A Review of School-Based Assessment' (ROSBA) was published in 1978, approved by State Cabinet in 1979 and announced by the then Minister for Education, the Hon. Val Bird, to be phased in over a five year period beginning in 1981.⁴⁵ That was over 28 years ago and it is essentially the system of externally-moderated school based assessment that we have in Queensland today.⁴⁶

In 1989, the Queensland Government decided to abolish the Tertiary Entrance (TE) Score as the main method of determining university offers. The Queensland Government asked Professor Nancy Viviani of Australian National University to review the system for the compilation of Tertiary Entrance Scores in Queensland and recommend an alternative to the TE Score.

Professor Viviani tabled her report in June 1990. The Viviani Report resulted in the establishment of the Tertiary Entrance Procedures Authority (TEPA) (now part of the QSA) and the introduction of a Student Education Profile (SEP) to replace the earlier TE score. The SEP comprised of results reported on the Senior Certificate (ie. subject results in the form of Levels of Achievement (VHA etc.) and results on the Queensland Core Skills Test) and results reported by TEPA on the Tertiary Entrance Statement (ie. aggregates in the form of Field Positions).

The Viviani Report recommended that systemic and independent research be conducted to determine how comparable assessment outcomes were across schools in Queensland given the system of school based assessment.⁴⁷ Since then, research has been conducted on the Queensland school based assessment system in terms of inter-marker reliability and teacher perception of consensus based moderation.⁴⁸

⁴² Ibid

⁴³ Ibid p3

⁴⁴ Ibid

⁴⁵ Ibid pp3-4

⁴⁶ Ibid p4

⁴⁷ Ibid p5

⁴⁸ Ibid

1.3.3 Current activity

The Australian curriculum

The new Australian curriculum for senior mathematics, chemistry and physics has a focus on developing students' investigative skills, the collection and analysis of qualitative and quantitative data, using intellectual rigour to evaluate claims and ability to communicate understandings. For example, the (draft) senior chemistry curriculum aims to develop students':

- ability to critically evaluate and debate scientific arguments and claims in order to solve problems and generate informed, responsible and ethical conclusions, and
- ability to communicate chemical understanding and findings to a range of audiences, including through the use of appropriate representations, language and nomenclature.⁴⁹

This reflects an approach to learning and teaching which has a focus on higher order thinking skills, and to teaching and assessment that supports that focus. This approach is also inherent in the Queensland syllabus. The foundational skills (formula, processes etc.) are taught as part of this – they need to be learnt for the student to be able to inquire, evaluate and communicate on the subject.

The QSA advises that the proposed national curricula for chemistry and physics will be largely the same as the current Queensland syllabus; and it is expected to closely align for mathematics A, B and C.

1.4 Report outline

This report is written in two parts: Part One describes key concepts informing the inquiry; the assessment system for senior mathematics, chemistry and physics; and presents data relating to participation and performance in these subjects at a state, national and international level. It also makes some comments in respect of that data.

Part One also describes the issues raised by submitters to this inquiry, and sets the scene for the consideration of those issues in Part Two.

Part Two discusses the issues, places them in the context of the key concepts and data presented in Part One, and draws on evidence from other sources which have informed the committee. Firstly it considers the broader issues which relate to the validity and reliability of the senior assessment system overall, and then the issues relating to senior mathematics, chemistry and physics more specifically. Part Two makes recommendations for the future.

⁴⁹ www.australiancurriculum.edu.au/SeniorSecondary/Science/Chemistry/RationaleAims.

See also: www.australiancurriculum.edu.au/SeniorSecondary/Science/Physics/RationaleAims
www.australiancurriculum.edu.au/SeniorSecondary/Mathematics/Essential-Mathematics/RationaleAims
www.australiancurriculum.edu.au/SeniorSecondary/Mathematics/General-Mathematics/RationaleAims
www.australiancurriculum.edu.au/SeniorSecondary/Mathematics/Specialist-Mathematics/RationaleAims

2 Key concepts

This chapter provides details of some of the key concepts informing the inquiry. Reference will be made to them throughout this report.

2.1 A crisis in maths and science education?

There are claims being made that “[s]cience education in Australia and in other post-industrial countries, is in a state of crisis.”⁵⁰

Our society and economy is increasingly technology-driven, and the knowledge and skills to drive innovation and creativity is vital for social and economic participation.

There are concerns about a lack of people in the workforce with these skills, decreasing enrolments in these subjects, lowered standards in these subjects at school and university, and a shortage of teachers of these subjects. If these concerns are founded, this suggests a significant negative impact on the future growth of our country.

Mathematics, chemistry and physics are not the only, or even the primary, subjects which promote development of knowledge and skills to drive innovation and creativity. However there is a strong relationship between these subjects and technological growth.

Several submitters to the inquiry, including the QSA, and research reports including those by the Australian Industry Group (AIG)⁵¹ and the Office of the Commonwealth Chief Scientist have pointed out that social and economic imperatives have led to a focus on development of what are commonly called ‘higher order’ skills⁵² – skills that go beyond the learning of basic knowledge. They include skills such as critical thinking, problem solving and communication. Because what is assessed drives what gets taught and learnt, assessment methods are central to ensuring those skills are learnt.

It is interesting that throughout history, what we value in education changes over time. Given the technological imperatives driving the global economy, mathematics and the ‘hard’ sciences are currently highly valued. The skills and thought processes required to think mathematically may be different from those required to analyse a piece of music or poetry, or to consider the implications of history for the future, and no doubt some people are innately stronger in it than others, and vice versa. But there is clearly a sense that higher order skills are the key to growth, irrespective of subject area.

⁵⁰ Tytler, Russell (2006) *Re-imagining Science Education: Engaging students in science for Australia's future*, p1

⁵¹ Australian Industry Group (2012) *A more competitive manufacturing industry – Management and workforce skills and talent*

⁵² QSA, Submission 129

2.2 The link between teaching, learning and assessment

Assessment cannot be considered in isolation from teaching and learning. What is assessed, is what gets taught and what gets learnt. And, what is to be taught should determine the methods and processes used to assess whether it has been learnt. The concept of ‘fitness for purpose’ is relevant here (see 2.4). As Professor Peter Galbraith told this inquiry:

*Assessment procedures should be constructed to validly and efficiently measure the particular type of knowledge that is the object of interest...*⁵³

This is echoed by the QSA:

Assessment is fundamental to the teaching and learning process as it provides students, parents and teachers with valuable information about individual student achievement.

Thus, in Queensland, assessment is used as an integral part of the teaching process. Teachers receive information from assessment processes, which they then use to determine how and what to teach students. Students receive information from assessment processes which tells them where they need to focus their learning efforts.

The QSA handbook states that:

*Research shows that quality learning outcomes for students are best produced when what is taught informs what is assessed, and when what is assessed forms the basis of what is reported.*⁵⁴

Assessment is linked to teaching and learning because:

- what is assessed, becomes what is taught
- the assessment method determines the teaching approach, and
- different content is suited to different assessment methods.

It became clear early on in this inquiry that some of the rationales for the criticism of senior assessment methods and processes for mathematics, chemistry and physics, were related to the syllabus content and pedagogy (methods of teaching).⁵⁵ This highlighted to the committee the strong interrelationship between teaching, learning and assessment.

As one education academic advised the committee, assessment needs to test:

*...what is it we want our school leavers to be able to do. I am glad those questions were raised because they are fundamental to curriculum development. They are not primarily assessment questions; they are curriculum questions.*⁵⁶

2.3 Lower and higher order skills

The concept of lower and higher order skills stems from an approach to classifying components of learning, the one most often referred to during this inquiry being Bloom’s

⁵³ Professor Peter Galbraith, submission 69, p3

⁵⁴ QSA, 2010. A-Z of senior moderation, p12

⁵⁵ Submissions 18, Merv Myhill; 19, Patrick Whalen; 28, Matthew Dean 255, Australian Family Association;

⁵⁶ Hansard, 1 May 2013, Professor Marilyn Goos, p10

taxonomy. Higher order skills are seen to require greater cognitive processing than the lower order skills of acquiring facts and concepts, but are more valuable as they are applicable much more widely than fundamental, subject-based facts and concepts, across learning contexts. The following are considered ‘higher order’ skills:

- Evaluation - Judging the outcome
- Synthesis - Putting together
- Analysis - Taking apart
- Application - Making use of knowledge.⁵⁷

A 2004 ACER research document provides a rationale for acquiring higher order skills as follows:

In today’s world it is necessary, but not sufficient, for students to achieve minimal competence in areas such as reading, writing and numeracy. Beyond the achievement of minimal competence, students also need to develop what are often called ‘higher order’ thinking skills including critical literacy, critical numeracy and cross-curricular competencies.

A useful conceptualisation of higher order thinking skills distinguishes two contexts in which these skills are employed: contexts where the thought processes are needed to solve problems and make decisions in everyday life; and contexts where mental processes are needed to benefit from instruction, including comparing, evaluating, justifying and making inferences (Wheeler & Haertel, 1993). The ability to employ higher order thinking skills in both these contexts is seen as essential in a rapidly changing world and the first context in particular is being adopted as a starting point for international assessment programs.⁵⁸

The aim of developing higher order skills is implicit in the Queensland senior syllabus (and is a goal of many modern curriculums, including the internationally regarded International Baccalaureate). However, some submissions to this inquiry indicate that this aim is at the expense of teaching ‘lower order’ skills – the fundamental content knowledge for mathematics, chemistry and physics. For example, Dr Matthew Dean advised the committee that:

Unfortunately, many students arriving the University of Queensland to study degrees in science or engineering, do not have fundamental (high school) mathematics skills required for these degrees. Many of these students even do not know the times-tables, or how to add fractions.⁵⁹

Evidence taken by the committee suggests that some of the current assessment methods for senior mathematics, chemistry and physics may be good for assessing achievement of ‘higher order’ skills. Others, such as supervised assessments (tests and exams) are well placed to assess ‘lower order’ skills such as core content knowledge.

⁵⁷ www.popet.com.au/higher_order_thinking

⁵⁸ Forster, Margaret (2004) *Thinking skills*, Research Developments, Vol 11, Art.1

⁵⁹ Submission 28, Dr Matthew Dean, p1

A standards-based assessment system is well placed to assess higher order skills. However, some submissions argue for a simpler assessment system, for example one based on assessing how many questions a student gets right or wrong. This is seen by those submitters to be more appropriate than a standards-based approach for mathematics and science, because these subjects are, in contrast with humanities subjects, highly objective. An answer is either correct, or it is not; and to attempt to assess tasks that aim to demonstrate core content knowledge using descriptive terms is unnecessarily complicated, as well as invalid.⁶⁰

The standards-based approach, using the criteria set for each of the subjects in question, supports the belief that learning occurs as learners are actively involved in a process of meaning and knowledge construction and not simply passively receiving information. The assessment tasks become part of the learning process in a context of continuous assessment, with students asked to demonstrate that they not only remember content knowledge, but understand it and can apply it in practice. This emphasises depth of learning.

The modern understanding of learning is that it is not necessarily linear and sequential, but that students best achieve depth of understanding through interpretation and construction of knowledge and skills.⁶¹ This view aligns with the views expressed by the AIG and the Commonwealth Office of the Chief Scientist about the need for schools to produce students who can think creatively and innovatively for our country's future.

The QSA has emphasised that content knowledge is still very much a part of the current syllabus:

*Knowledge and facts are still critically important in physics, chemistry, maths C and maths B. They have not been thrown out the door. In the excerpts of the syllabuses that we have shown previously, knowledge and procedures are the objectives so they must be covered.*⁶²

Indeed, the Physics syllabus specifies:

Knowledge and conceptual understanding

Students should acquire knowledge and construct understanding of facts, theories, concepts and principles of physics. To work scientifically, students need to have an understanding of underlying scientific knowledge, including the associated mathematical skills. They need to engage with the processes and phenomena observed in Physics through characteristics of data analysed. Students need to make informed judgments based on sound reasoning in order to direct them in their scientific endeavours and to engage with problem solving.

By the end of this course, students should be able to:

- ***recall and interpret concepts, theories and principles of Physics*** —*this includes the abilities to remember, reproduce and interpret subject matter such as facts, definitions, formulas, terminology, concepts, theories,*

⁶⁰ See, for example, submission 8, name suppressed

⁶¹ See IBO, S 2.4

⁶² Hansard, 20 March 2013. Mrs Patrea Walton, p11

principles, laws, procedures, sequences, events, diagrams, symbols, figures, systems and patterns

- **describe and explain processes and phenomena of Physics —this includes the abilities to compare and classify the concepts, theories and principles being explored, based on primary and secondary data**
- **link and apply algorithms, concepts, theories and schema of Physics —this includes the abilities to adapt, translate and reconstruct understandings in order to find solutions.**⁶³

Teaching and learning in Queensland occurs through a range of methods, including direct instruction, as well as through the more active teaching and learning that now characterises the approach to teaching and learning in Australia and many other western countries. Teachers use their professional skills to determine the most appropriate pedagogy in a given set of circumstances.

Tasks are set which specifically aim to allow the student to demonstrate their standard of achievement against the knowledge and procedures criteria. The syllabus document describes the features of each standard of achievement from A to E for each of the exit criteria. For example, Table 1 below shows the exit criteria-standards rubric for senior physics, in respect of the knowledge and procedures criteria:

Knowledge and procedures

A	B	C	D	E
<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> • reproduction and interpretation of complex and challenging concepts, theories and principles • comparison and explanation of complex concepts, processes and phenomena • linking and application of algorithms, concepts, principles, theories and schema to find solutions in complex and challenging situations. 	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> • reproduction and interpretation of complex or challenging concepts, theories and principles • comparison and explanation of concepts, processes and phenomena • linking and application of algorithms, concepts, principles, theories and schema to find solutions in complex or challenging situations. 	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> • reproduction of concepts, theories and principles • explanation of simple processes and phenomena • application of algorithms, principles, theories and schema to find solutions in simple situations. 	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> • reproduction of simple ideas and concepts • description of simple processes and phenomena • application of algorithms, principles, theories and schema. 	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> • reproduction of isolated facts • recognition of isolated simple phenomena • application of simple given algorithms.

Table 1: Exit criteria-standards rubric for senior physics in respect of knowledge and procedures criteria

The syllabus also describes in detail the areas of study and key physics concepts that should be taught in the course, and directs that the course should be sequenced to increase in complexity over the two senior years.

⁶³ Queensland Studies Authority, 2007. Senior Physics Syllabus

The other criteria for senior physics are ‘investigative processes’ and ‘evaluating and concluding’. The standards for the former are specified as follows:

Investigative processes

A	B	C	D	E
<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> • formulation of justified significant questions/hypotheses which inform effective and efficient design, refinement and management of investigations • assessment of risk, safe selection and adaptation of equipment, and appropriate application of technology to gather, record and process valid data • systematic analysis of primary and secondary data to identify relationships between patterns, trends, errors and anomalies. 	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> • formulation of justified questions/hypotheses which inform design and management of investigations • assessment of risk, safe selection of equipment, and appropriate application of technology to gather, record and process data • analysis of primary and secondary data to identify patterns, trends, errors and anomalies. 	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> • formulation of questions and hypotheses to select and manage investigations • assessment of risk, safe selection of equipment, and appropriate application of technology to gather and record data • analysis of primary and secondary data to identify obvious patterns, trends, errors and anomalies. 	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> • implementation of given investigations • safe use of equipment and technology to gather and record data • identification of obvious patterns and errors. 	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> • guided use of given procedures • safe directed use of equipment to gather data • recording of data.

Table 2: Standards rubric for senior physics in respect of investigative processes

To achieve a high standard against this criteria, a student would clearly need to demonstrate that they have undertaken an investigation. It would seem difficult to assess this criteria without a task that asked the student to actually undertake an investigation.

2.4 Fitness for purpose

There is significant evidence, and it seems obvious to the committee, that assessment should be ‘fit for purpose’: that different types of assessment tasks provide the most valid assessments of different types of learning; and that different assessment tasks are suitable for different purposes (eg. for ranking students against each other, or for assessing particular parts of the syllabus; or for assessing a student’s level of achievement against pre-defined standards).

This concept offers a helpful way of reconciling some of what appear to be the entrenched, and on the face of it, opposing positions expressed during this inquiry.

2.4.1 Assessing different types of learning and different content

A more traditional, linear approach to learning breaks complex knowledge and skills into separate blocks of learning that can be tested separately, in sequential order from simple to complex. Pen and paper testing, using numeric marks that can be added up to reach a total score, fits well with teaching and learning that is structured that way.

A key argument put to the committee by many submitters is that the basic content knowledge must be learnt before higher order skills can be learnt and applied.⁶⁴ The concern raised is that assessing students on tasks like extended investigations, where a student demonstrates their understanding of the basic content knowledge through application, and demonstrates higher order skills such as analysis, synthesis and communication, is taking the teaching and learning focus away from the content knowledge, when the student has not yet mastered the content. Further, assessing students on those higher order skills is seen as inappropriate and stressful for the student when they are still learning the underpinning content knowledge.

It might be that the answers to some criticisms of the current assessment process – for example that the focus on extended investigation tasks detract from time available to teach content knowledge – could lie in the relative emphasis on assessment of knowledge and content, to that on assessment of higher order skills in these subjects. The committee makes some recommendations to this effect in Part Two of this report.

2.4.2 Assessing for different purposes

Academics who participated in the committee’s expert advisory forum on 1 May 2013 considered the purpose of senior assessment and in particular, whether the “end game” for senior studies in mathematics, chemistry and physics was university study, or a mathematically and scientifically literate population. The following quote sums up some of that discussion:

*When we talked about fitness for purpose....really it depends on what the outcome of the assessment or the actual course is. You could look at it from three different perspectives, and we are not making a judgement about any of these three. If you look at it that students are undertaking education for an individual purpose, then the assessment would be based on what does that individual actually know and are they able to do that thing. If it is for university, obviously that actually would inform the purpose of the assessment. Again, from a VET perspective, our assessment is very much on employment outcomes, so is it that the assessment in chemistry, physics and maths should be for university, or should it actually be for employment purposes? These are the things that would inform fitness for purpose.*⁶⁵

Among submissions, too, there were different views about whether senior learning in these subjects is to prepare students for university entry, or to support general social and economic participation, including employment, in an era of rapid technological growth.

A key question posed during the forum discussion was whether one learning and assessment process can achieve both the requisite knowledge for university study in that subject, and the goal of general mathematical or scientific literacy.

There was no consensus amongst the academics from the various mathematics and science related disciplines who gave evidence to this inquiry about whether the current approaches to senior teaching, learning and assessment in Queensland were appropriate for university;

⁶⁴ Dean, AFA, Sub 64, others

⁶⁵ Hansard, 1 May 2013, Ms Ailsa Leacy, p3

or whether the goal of senior courses of study in those subjects (and thus, the determinants of achievement levels) ought to be preparation for university in any event.

The education academics on the other hand were fairly consistently of the view that senior teaching, learning and assessment was for broad social and economic participation. This supports the goals of higher order skills development.

In her summing up of a group presentation at the expert advisory forum, the facilitator said:

*The links between curriculum, learning and assessment group....had a discussion about the fact that people do not arrive at universities, for instance, or where the schools feed into, knowing enough. There is a multiple set of causes for that, but there is the need for assessment to give confidence that students know enough to succeed. So succeeding at uni would mean a common foundation knowledge plus the ability to acquire knowledge.*⁶⁶

And a participant, Professor Peter Lindsay, stated:

*...when we say, 'Are we happy with the assessment regime? Is it valid?', it may be a valid tool for deciding who has passed high school. But whether the current system is producing a valid predictor of success at university is a very separate question. They have different demands and they do not overlap. How you would decouple them I think would be very difficult, because then you are making students do one set of tasks for one purpose and then do you have them do a different set for another one? But at the moment the same scheme where we are trying to ask, 'Is it reliable? Is it valid?', we are actually looking for it to serve multiple purposes and to be valid for both.*⁶⁷

While the committee did not receive submissions from industry, employer or community groups, recent reports from bodies such as the AIG claim that it is critical that higher order thinking skills, which support innovation and creativity, be a focus of learning in order to ensure the country's economic growth.

The syllabus documents for all of the mathematics subjects reflect a goal of participating fully in lifelong learning, and the chemistry and physics, of scientific literacy as a way to understand the world and as a stepping stone to further study. The syllabuses also recognise the intrinsic 'hands on' nature of these subjects.

The QSA syllabus documents for mathematics B and C suggest that they are recommended precursors for tertiary study in subjects with high demand in mathematics, with mathematics A suitable as a precursor for tertiary study in subjects with moderate demand in mathematics. The chemistry and physics syllabus do not specify their relationship to tertiary studies.

The committee met with curriculum and assessment officials as well as teachers and some academics from other jurisdictions in the course of this inquiry. It seems that the concerns about senior level mathematics, chemistry and physics students not being university ready are fairly universal – as are concerns about primary school graduates not being ready for

⁶⁶ Hansard, 1 May 2013, Ms Mary Maher, p6

⁶⁷ Hansard, 1 May 2013, Professor Lindsay, pp8-9

secondary school study in these subjects. These concerns are discussed further in the chapter on Participation (chapter 5).

Committee comment

The committee notes that the consideration about the role of senior assessment in respect of tertiary entry is broader than the scope of this inquiry, although not unrelated; and given the terms of reference for the government's commissioned review of senior assessment and tertiary entrance processes, it is likely that review will consider this question in some detail.

However in respect of mathematics, chemistry and physics, the committee makes some recommendations in Part Two of this report which might, in changing the way assessment occurs, increase the emphasis on the content knowledge which appears to be the key concern of academics from these disciplines, without negating the goal of increasing the relevance of these courses of study and the learning of higher order skills, through allowing an investigative approach to learning where that is appropriate.

2.5 What is the information about overall achievement used for?

If assessment is to provide certification that a particular level of achievement on specified criteria has been reached, then standards-based assessment – measuring students against pre-defined levels of achievement on the various course criteria is more appropriate. If assessment is to support competitive selection, such as for university, then measuring students against each other is appropriate (though there would also need to be some assurance that specified standards had been met). Queensland's certification system is separate from its selection system, with the selection (OP) system an optional add-on for those students seeking university entry. Other jurisdictions also attempt to do both, mainly using statistical scaling for the latter, like Queensland.

Where assessment is needed to support competitive selection, such as for university entrance, then measuring students' achievements against each other is appropriate. Queensland's certification system is separate from its competitive selection system, with the selection (OP) system an optional add-on for those students seeking university entry.

In Finland, often held up as an example of excellence, school-based assessment occurs all year, followed by external exams. Universities then run their own entrance exams.

2.6 The syllabus

The syllabus is the document that brings together the directives about what is to be taught and learnt, and how that learning is to be assessed. A number of inquiry participants told the committee that teachers follow the syllabus as closely as possible, including the process outlined in it. The syllabus content in respect of teaching and learning is not explicitly within the terms of reference for the inquiry, and the committee does not intend to focus on that in this report. However, as the syllabus is the basis of assessment in that it outlines what it is that is to be taught, learnt, and thus assessed, and because appropriate assessment methods are dependent on what is meant to be taught, some of the committee's findings and recommendations will relate to the syllabus.

These are limited to findings and recommendations about the clarity and level of detail in the syllabus, and the relative degree of focus on each of the three criteria (or learning domains) for each of the three subjects within scope for this inquiry.

2.7 Definition and purpose of assessment

Concepts the committee heard many times throughout the inquiry process were ‘assessment of learning’, and ‘assessment for learning’, used to contrast two views of assessment. The submission from ACER described assessment of learning as follows:

*Under this traditional view, teaching, learning and assessment occur sequentially: teachers teach, students learn, and tests and examinations are used to determine how much of what has been taught students have successfully learnt.*⁶⁸

ACER then described assessment for learning as follows:

*Teachers use assessments to identify where individual students are in their learning, to diagnose errors and misunderstandings, to plan teaching, to provide feedback to guide student effort, to monitor the progress that individuals make over time, and to evaluate the effectiveness of their teaching strategies and interventions. In this sense, assessment has parallels with assessment in other professions such as medicine and psychology where the purpose is not so much to judge as to understand for the purposes of making informed decisions.*⁶⁹

Mrs Walton also referred to assessment as learning:

*Assessment as learning occurs when students reflect on their own progress to inform their future learning...*⁷⁰

The Queensland approach to assessment aims to use a greater understanding of learning to identify what action is needed and at what points, to monitor progress, and to evaluate effectiveness. Some of the submissions calling for change in Queensland want a focus on the more traditional use of assessment – to validly judge students’ achievement against each other, and to promote learning of the fundamental content knowledge.

As ACER and others such as Professor Peter Galbraith point out, these are not necessarily competing views of assessment.⁷¹ An assessment process can achieve both aims.

There is a fairly consistent view expressed by ACER that better evidence about the strengths and limitations of current assessment tools, including tests and extended investigations, should be obtained before any major changes to the current system of assessment occurs.⁷²

⁶⁸ ACER, submission 58, p1

⁶⁹ Ibid

⁷⁰ Hansard, 7 March 2013, Mrs Walton, p3

⁷¹ Honorary Professor Peter Galbraith, Submission 69, p1

⁷² Hansard, 1 May 2013 and Hansard, 5 June 2013; Masters, 2012 and Stanley 2013

2.8 Validity and reliability

These concepts are defined by the International Baccalaureate Organisation (IBO) as follows:

Validity: *the extent to which an assessment measures what it is stated to measure.*⁷³

Reliability: *the accuracy of measurement resulting from an assessment. How likely it is that the same result would be produced in slightly different circumstances including by different markers. Reliability can be tested by whether the student would gain the same result were he/she to repeat the assessment on different occasions, and also given the same result if the assessment were marked by different markers.*⁷⁴

A reliable assessment is one in which a student has shown a repeated demonstration of knowledge over time, and even better, in different ways. Consistent performance results are more likely to be reliable.

Committee members found the following analogy supported their understanding of these concepts:

*Reliability and validity are closely related. To better understand this relationship, let's step out of the world of testing and onto a bathroom scale. If the scale is reliable it tells you the same weight every time you step on it as long as your weight has not actually changed. However, if the scale is not working properly, the number may not be your actual weight. If that is the case this is an example of a scale that is reliable, or consistent, but not valid. For the scale to be valid and reliable, not only does it need to tell you the same weight every time you step on the scale, but it also has to measure your actual weight..... A test can be reliable without being valid. However, a test cannot be valid unless it is reliable.*⁷⁵

Confidence that the senior assessment system is both valid and reliable is critical, in terms of Queensland's broader and individual economic outcomes. At the local level, employers, industry and higher education institutions need to be able to rely on the senior assessment system to have made a valid assessment of a potential employee or student, in order to inform their decisions about investment in that student as an employee or higher education student.

As well, education is one of Queensland's key exports in the context of a global education market; and confidence in the state's educational standards is key to maintaining that position. Valid and reliable senior assessment is critical to that confidence.

2.9 Moderation

The purpose of moderation is to ensure comparability of assessed achievement levels, between students and schools; that is, that teachers are making consistent judgments about standards of achievement. Every Australian jurisdiction has some form of moderation.

⁷³ IBO, p8

⁷⁴ Ibid

⁷⁵ www.cal.org/flad/tutorial/reliability/3andvalidity.html

Two broad categories of moderation approaches are social moderation, and statistical moderation. Moderation can test reliability: the more times different assessors come to the same judgement about achievement level on one task, the more reliable that assessment is likely to be.

Queensland's senior assessment system uses social moderation, with panels of teachers from different schools in a district, reviewing samples of work from each senior subject, at each school within their district. The school-based assessment for a class of students can be marked up or down, where the panel's assessments (after discussion and debate which are a central part of the moderation process) disagree with the school's assessment on any of the sample tasks.

Statistical moderation is used in some other jurisdictions, such as Victoria, where a common exam based on the syllabus for each subject is compared with the school-based assessment for a class group of students. The school-based assessments for a class can be marked up or down, depending on the exam score. The exam score, based on a common task (the exam), is taken to be the more reliable indicator.

Statistical moderation is used in Queensland as part of the calculating the Overall Position (OP) for students.⁷⁶ In addition, the Queensland Core Skills (QCS) Test:

... contributes information for the calculation of Overall Positions (OPs) and Field Positions (FPs), which are used to rank students for tertiary entrance. A student's individual QCS Test result is not used on its own in the calculation of their OP. Instead, group results from the test are used as part of statistical scaling processes.”⁷⁷

⁷⁶ QSA, Calculating Overall Positions – the basic principles, p3

⁷⁷ QSA, School-based assessment – the Queensland system, p15

3 Senior assessment in Queensland

3.1 The school-based, standards-based system

A broad description of Queensland's senior assessment system is that:

Teachers use syllabuses to design teaching, learning and continuous school-based assessment programs and to make judgments about student achievement.

Judgments about the quality of student achievement are made using pre-stated standards described in syllabuses about how well students have achieved the syllabus general objectives.

Evidence, collected over time across a range of techniques and contexts, is used to make judgments about students' levels of achievement.

These judgments are then moderated, using a social moderation mechanism, to ensure consistency across the state.⁷⁸

3.1.1 Queensland Core Skills Test

Queensland's Core Skills (QCS) Test is primarily a scaling instrument to support the calculation of Overall Positions (OPs) which are used for tertiary selection. It assists to more finely 'rank' students in the high stakes university entrance process across all schools rather than within schools, as occurs with the school based assessment. It does not aim to test students against the syllabus for any specific subject.

The QCS test is taken by all students who want to obtain a Queensland Certificate of Education at the end of Year 12, and not just students who intend to go to university. Given the large number of vocational study options in senior levels since a 2002 policy change that increased school retention rates to Year 12, only half of all Year 12 students seek to obtain an Overall Position (OP) score.

Comparability of school-assessed work can never be an exact science and will always involve judgement and constant attention in striking an appropriate balance between competing demands. Maintaining this balance is assisted when there are procedures which routinely provide statistical checks on the effectiveness of the process and when the process itself values and enhances professional judgements.⁷⁹

One submission⁸⁰ argued that the QCS test showed that current assessment systems were not valid. It presented data that showed some year 12 students' scores on the QCS test questions that relate to numeracy, which are set at the year 10 level, to be very inconsistent with those student's (school-based) assessed achievements in Year 12 mathematics.

However, given the QCS test does not aim to test the curriculum, but general constructs about numeracy, this might suggest a problem more with the curriculum than the assessment methods. Inconsistent QCS test scores also provide an indicator of a potential issue, which is then flagged for investigation. Thus, while not designed for that purpose (it is

⁷⁸ QSA Moderation Handbook for Authority Subjects, p5

⁷⁹ Hill *et al*, 1997, p46

⁸⁰ Submission 121

designed to scale student results, as part of the OP process for students seeking tertiary entry), the QCS test can be part of the validation process.

3.1.2 QSA Senior External Examination

There is also the option of assessment for Year 12 by sitting external examinations set by the QSA.

The following information is taken from the QSA website:

The Senior External Examination consists of 22 individual subject examinations provided across Queensland in October and November each year. Results are based solely on examination performance. Any class tests or assignments completed during the year will not contribute to results. This differs from the system of externally moderated school-based assessment in place in Queensland secondary schools.

The Senior External Examination is for:

- *Year 12 students unable to access particular subjects at their school*
- *adult students (people of any age not enrolled at a Queensland secondary school):*
 - *to meet tertiary entrance or employment requirements*
 - *for personal interest.*

Candidates may be able to use Senior External Examination results to gain a Queensland Certificate of Education (QCE).

Each subject examination is held only once each year. See important dates and examination timetable.

Results are reported as one of five levels of achievement:

- *Very High Achievement*
- *High Achievement*
- *Sound Achievement*
- *Limited Achievement*
- *Very Limited Achievement.*

There are no pass or fail grades, nor are results recorded as numbers, marks or percentages. Results are not published in newspapers or on the QSA website.⁸¹

The website also advises that the external exams are to be phased out:

Following an extensive consultation process, the Queensland Studies Authority has decided to phase out the examinations for non-language subjects over the next three years.

⁸¹ <http://www.qsa.qld.edu.au/2423.html>

Options for Year 12 students wishing to study non-language subjects after 2015 include studying through a shared campus arrangement or enrolling at a school of distance education.

Adult students wishing to study non-language subjects after 2015 may be able to enrol in teaching centres offering externally moderated school-based assessment of student achievement.

From 2016, the Senior External Examination will consist of foreign language subject examinations only (Arabic, Chinese, Korean, Modern Greek, Polish, Punjabi, Russian, Spanish and Vietnamese).⁸²

3.2 Assessment of senior mathematics, chemistry and physics

3.2.1 Queensland

The current senior syllabuses for chemistry and physics (the 2007 syllabuses) were approved for first use in 2008. The current senior syllabuses for mathematics A, B and C (the 2008 syllabuses) were approved for first use in 2009.

Assessment in mathematics, chemistry and physics in Queensland is against three fixed criteria, which are fairly similar for each of the three subjects in scope:

Mathematics A

Knowledge and procedures

This criterion refers to the student's ability to access, select and apply mathematical definitions, rules and procedures, and to demonstrate application of sequences of mathematical procedures, with and without the use of mathematical technology.

Modelling and problem solving

This criterion refers to the student's ability to model situations using mathematical constructs, select and apply appropriate strategies, investigate situations mathematically, provide solutions and make informed decisions using mathematical reasoning.

Communication and justification

This criterion refers to the student's ability to interpret, translate, communicate, present and justify mathematical arguments and propositions, using mathematical and everyday language and symbols to develop logical supported arguments.

Mathematics B

Knowledge and procedures

This criterion refers to the student's ability to recall, access, select and apply mathematical definitions, rules and procedures, to demonstrate numerical and spatial sense and algebraic facility, with and without the use of mathematical technology.

⁸² <http://www.qsa.qld.edu.au/588.html>

Modelling and problem solving

This criterion refers to the student's ability to apply problem-solving strategies to investigate and model situations, generate and use data, analyse and interpret results in the context of problems to investigate the validity of mathematical arguments and models.

Communication and justification

This criterion refers to the student's ability to interpret, translate, communicate, present and justify mathematical arguments and propositions, using mathematical and everyday language and symbols to develop logical supported arguments.

Mathematics C

Knowledge and procedures

This criterion refers to the student's ability to recall, access, select and apply mathematical definitions, rules and procedures, to demonstrate numerical and spatial sense and algebraic facility, with and without the use of mathematical technology, and to demonstrate knowledge and application of the nature of mathematical proof.

Modelling and problem solving

This criterion refers to the student's ability to apply problem-solving strategies to investigate and model situations, generate and use data, analyse and interpret results in the context of problems to investigate the validity of mathematical arguments and models, and, when appropriate, modify mathematical models.

Communication and justification

This criterion refers to the student's ability to interpret, translate, communicate, present, justify and prove mathematical arguments and propositions, using mathematical and everyday language and symbols to provide supporting arguments in the form of proof.

Chemistry

Knowledge and conceptual understanding

This criterion refers to the student's ability to acquire knowledge about facts, theories, concepts and principles of chemistry, to engage with the theories and issues of chemistry, and to interpret the interrelationships occurring within chemical contexts.

Investigative processes

This criterion refers to the student's ability to recognise the methodologies available to them, conduct experimental processes safely, judge the worth of qualitative data, and interpret and apply the outcomes of quantitative data.

Evaluating and concluding

This criterion refers to the student's ability to synthesise their thoughts and the thinking of others, determine interrelationships, propose solutions and justify decisions, and communicate their findings.

All criteria make equal contribution to the determination of levels of achievement.

Physics

As for chemistry, that is:

Knowledge and conceptual understanding

This criterion refers to the student's ability to acquire knowledge about facts, theories, concepts and principles of physics; to engage with the theories and issues of physics; to interpret the interrelationships and predict outcomes occurring within physical contexts.

Investigative processes

This criterion refers to the student's ability to recognise the methodologies available to them, to conduct experimental processes safely, to judge the worth of qualitative data, and to interpret and apply the outcomes of quantitative data.

Evaluating and concluding

This criterion refers to the student's ability to synthesise their thoughts and the thinking of others, determine interrelationships, propose solutions and justify decisions, and communicate their findings.

All criteria make equal contribution to the determination of levels of exit achievement.⁸³ Assessment processes aim to determine to what standard a student has achieved each criteria.

Assessment tasks are developed by a school as part of its work program for each subject. The work program must be approved by the QSA (via review panels). Work program approvals are valid for five years. Some assessment tasks are mandated, for example a work program must include one extended investigation or modelling type task in Year 11 and Year 12, for each of the senior subjects that are in focus for this inquiry; and four to six supervised assessment tasks – usually exams or tests.

Assessment is undertaken by classroom teachers, and based on the exit criteria and the specified standards of achievement for each of the criteria as contained in the syllabus. A criteria sheet aligning with the exit standards must be developed for each assessment task.

Assessment is moderated by a system of peer review. Panels of experienced teachers from schools within a district, and then across the state, review samples of a school's assessments for comparability with other schools, to ensure validity of the school-based assessment. Discussion and debate is a key part of the moderation process, in which a teacher's assessments for a subject may be adjusted up or down. Participating on panels is seen as a valuable professional development experience for teachers.

A student's grade on an individual piece of assessment is recorded on a scale from A to E, based on a criteria sheet, or marking rubric, developed by the teacher and aligned with the standards specified for each of the three criteria for the course, with teachers making judgements about the standard of achievement a student has reached. This example of a criteria sheet was provided to the committee during the inquiry.⁸⁴

⁸³ QSA, Senior Syllabus, Mathematics A, Mathematics B, Mathematics C, Chemistry and Physics

⁸⁴ Name suppressed, Submission 121, p16

	Section of the report	Standard A	Standard B	Standard C	Standard D	Standard E
KCU Recall and interpret concepts, theories and principles	Introduction	Reproduction and interpretation of complex and challenging energy/corrosion concepts, theories and principles.	Reproduction and interpretation of complex or challenging energy/corrosion concepts, theories and principles.	Reproduction of energy/corrosion concepts, theories and principles.	Reproduction of simple energy/corrosion ideas and concepts.	Reproduction of isolated energy/corrosion facts.
KCU Describe and explain processes and phenomena	Discussion	Comparison and explanation of complex energy/corrosion concepts, processes and phenomena.	Comparison and explanation of energy/corrosion concepts processes and phenomena.	Explanation of simple energy/corrosion processes and phenomena.	Description of simple energy/corrosion processes and phenomena.	Recognition of isolated simple energy/corrosion phenomena.
KCU Link and apply algorithms, concepts, theories and schema	Discussion	Linking and application of algorithms, concepts, principles, theories and schema to find solutions in complex and challenging energy/corrosion situations.	Linking and application of algorithms, concepts, principles, theories and schema to find solutions in complex or challenging energy/corrosion situations.	Application of algorithms, principles, theories and schema to find solutions in simple energy/corrosion situations.	Application of algorithms, principles, theories and schema about energy/corrosion.	Application of simple given algorithms about energy/corrosion.
IP Conduct and appraise chemical research tasks	Introduction, journal	Formulation of justified significant questions/hypotheses which inform effective and efficient design, refinement and management of the energy/corrosion investigation.	Formulation of justified questions/hypotheses which inform design and management of the energy/corrosion investigation.	Formulation of questions and hypotheses to select and manage the energy/corrosion investigation.	Implementation of given investigation about energy/corrosion.	Guided use of given procedures for energy/corrosion.
IP Operate chemical equipment and technology safely	Materials and equipment	Assessment of risk, safe selection and adaptation of equipment, and appropriate application of technology to gather, record and process valid data about energy/corrosion.	Assessment of risk, safe selection of equipment, and appropriate application of technology to gather, record and process data about energy/corrosion.	Assessment of risk, safe selection of equipment, and appropriate application of technology to gather and record data about energy/corrosion.	Safe use of equipment and technology to gather and record data about energy/corrosion.	Safe directed use of equipment to gather data about energy/corrosion.
IP Use primary and secondary data	Discussion	Systematic analysis of primary and secondary energy/corrosion data to identify relationships between patterns, trends, errors and anomalies.	Analysis of primary and secondary energy/corrosion data to identify patterns, trends, errors and anomalies.	Analysis of primary and secondary energy/corrosion data to identify obvious patterns, trends, errors and anomalies.	Identification of obvious energy/corrosion patterns and errors.	Recording of energy/corrosion data.
EC Determine, analyse and evaluate the chemical interrelationships involved	Discussion	Analyses and evaluates complex energy/corrosion scientific interrelationships	Analyses complex scientific energy/corrosion interrelationships	Describes scientific energy/corrosion interrelationships	Identifies simple scientific energy/corrosion interrelationships	Identifies obvious scientific energy/corrosion interrelationships
EC Predict chemical outcomes and justify conclusions and recommendations	Conclusion	Explore scenarios linked to the research focus, suggesting possible outcomes, and generates justified conclusions/recommendations.	Explains scenarios linked to the research focus, suggesting possible outcomes, and discuss conclusions/recommendations.	Describes scenarios linked to the research focus, suggesting possible outcomes with statements about conclusions and recommendations.	Identifies scenarios linked to the research focus or suggests possible outcomes.	Makes statements about outcomes.
EC Communicate chemical information in a variety of ways	Method, Introduction, Results, Discussion, Conclusion	Discriminating selection, use and presentation of scientific data and ideas about energy/corrosion to make meaning accessible to intended audiences through innovative use of range of formats.	Selection, use and presentation of scientific data and ideas about energy/corrosion to make meaning accessible to intended audiences in range of formats.	Selection, use and presentation of scientific data and ideas about energy/corrosion to make meaning accessible in range of formats.	Presentation of scientific data or ideas about energy/corrosion in range of formats.	Presentation of scientific data or ideas about energy/corrosion.

Table 3: Example of a criteria sheet

A student's overall grade for the course is reported as one of five levels of achievement:

- Very High Achievement
- High Achievement
- Sound Achievement
- Limited Achievement
- Very Limited Achievement.

Guidance is provided by the QSA as to which of the overall grades should apply, dependent on the number of A's, B's etc. received for the assessment tasks set over the course of study (see chapter 10, The marking regime).

There is criticism that this process for assessing a student's level of achievement is too subjective, and essentially amounts to little more than a "guess".⁸⁵ Other teachers have taken some exception to this and claim that as professionals, they "*use much more systematic and intelligent versions of the process to come to a meaningful decision.*"⁸⁶

3.2.2 Other jurisdictions

The assessment systems of New South Wales and Victoria were frequently held up to the committee by those critical of the Queensland system, as having elements that Queensland might usefully adopt. In particular, numerical marking systems (in the context of a standards-based approach) and external exams were seen as valuable.

New South Wales

New South Wales is also an explicitly standards-based system. Higher School Certificate (HSC) is a one year course undertaken in Year 12. Fifty per cent of a student's overall achievement mark for the course is derived from school-based assessment, and fifty per cent from a subject based external exam. A statistically moderated (via the exam) school-based mark and the exam mark are added together for the student's overall assessment mark. School-based assessment is used to measure performance on a wider range of course outcomes than can be tested in an external examination.

Internal assessment tasks (three to five over Year 12) are set by the teacher, within broad parameters outlined in the syllabus. A typical assessment task in physics might include an element of secondary research, individual primary research, and presentation of findings. Marking guidelines have to set out what values are associated with different aspects of the task (eg 12 marks for communication, 20 for knowledge, etc.).

While an extended investigation must be undertaken in each of the relevant subjects during Year 12, it is up to the school to decide whether that task contributes to the student's school-based assessment.

Weighting is used for each component or, to compare with Queensland terminology, each criteria. For example, knowledge and understanding represents 40% of the chemistry internal assessment mark, while investigation and communication skills are worth 30% each.

The overall mark (the moderated school-based and the exam-based mark added together) is then compared back to a 'performance band' which shows what the mark means the student can do: this makes it meaningful to those involved in the student's future direction.

This is an example of the performance band for Physics in 2012⁸⁷:

Physics, 2012, Candidature - 9511

Band 6

(7.93%)

Demonstrates an extensive knowledge and understanding of the concepts of the physics course content including context, prescribed focus areas and domain. Displays an outstanding ability to describe and explain physics concepts, including abstract ideas, clearly and accurately, and to apply the concepts to unfamiliar situations. Applies a high level of critical thinking skills in developing appropriate solutions to problems involving a long sequence of related tasks. Analyses, evaluates and extrapolates data effectively,

⁸⁵ Hansard, 7 March 2013, Professor Peter Ridd, p18; Submission 91, Rebecca Andrews, p1

⁸⁶ For example, submission 193, Andrew McCosh, p2

⁸⁷ Available at http://www.boardofstudies.nsw.edu.au/ebos/static/BDHSC_2012_12_15330.html

identifies complex relationships, quantifies explanations and descriptions, and synthesises information to draw conclusions. Communicates succinctly, logically and sequentially using a variety of scientific formats. Demonstrates a high level ability to design an experimental procedure.

Band 5

(26.12%)

Demonstrates a thorough knowledge and understanding of the concepts of the physics course content including context, prescribed focus areas and domain. Effectively communicates a detailed understanding of physics concepts using appropriate physics terminology and some illustrative examples, and applies the concepts to unfamiliar situations. Analyses information given in written, tabular, graphical and diagrammatic form and relates this to other relevant information. Displays competence in manipulating equations to solve problems involving a number of steps. Demonstrates a thorough knowledge of the use of appropriate experimental procedures.

Band 4

(33.02%)

Demonstrates a sound knowledge and understanding of the concepts of the physics course content including context, prescribed focus areas and domain. Describes concepts and information clearly in written and graphical forms and applies these concepts in familiar situations. Demonstrates a broad ability to carry out calculations and/or substitute into equations and to use relevant symbols and units when manipulating data. Displays proficiency in selecting relevant data from information given in written, tabular, graphical and diagrammatic form. Describes correct apparatus for a particular physical measurement and has an adequate understanding of experimental methodology.

Band 3

(23.38%)

Demonstrates a basic knowledge and understanding of the concepts of the physics course content including context, prescribed focus areas and domain. Uses simple physics definitions and terms to communicate understanding of physics concepts. Substitutes data from information given in written, tabular, graphical and diagrammatic form. Draws simple diagrams and graphs to describe phenomena in physics.

Band 2

(6.93%)

Demonstrates a limited knowledge and understanding of the physics course content including context, prescribed focus areas and domain. Recalls elementary terminology and formulae related to some areas of physics. Interprets basic diagrams and graphs. Determines an appropriate scale for a graph.

Band 1

(2.15%)

A mark in this band indicates that the student has achieved below the minimum standard expected.

Victoria

As in Queensland, the senior programs of learning, known as the Victorian Certificate of Education (VCE) or the Victorian Certificate of Applied Learning (VCAL), which is a vocational stream, are two year, or four unit, programs. As in Queensland, teachers design VCE courses of learning based on the syllabus documentation. The syllabus documents are somewhat more prescriptive than Queensland's, and provide weightings for each task in terms of its contribution to the overall mark a student receives. The system is heavily focused towards 'ranking' of students achievement relative to each other - a 'bell curve' approach. In mathematics, chemistry and physics, external subject-based exam is worth 60% of the overall mark a student receives. The school-based tasks comprise the remaining 40%, and that mark is calculated numerically based on the sum of marks obtained for each assessment item.

Queensland is the only Australian state that does not use numeric indicators as a matter of course, and to use social moderation in senior assessment.

4 The issues

The evidence taken by the committee during this inquiry suggests that there are significant concerns about the way that senior mathematics, chemistry and physics are assessed in Queensland schools. These relate to teacher and student workloads; clarity about standards and grading; the perceived validity of current practices including moderation processes; teacher qualifications in the senior years and importantly, earlier years; university entry requirements; and the multiple purposes of senior education.

The perceived problems attributed to current approaches to assessment of senior mathematics, chemistry and physics in Queensland school are:

- A decline in mathematics, chemistry and physics enrolments⁸⁸
- A decline in mathematics, chemistry and physics performance by Queensland students⁸⁹
- Excess workloads for teachers and students, for no demonstrable benefit⁹⁰
- An inability of teachers, students and parents to understand the standards as written⁹¹
- Assessment methods are inappropriate for assessment of ‘the basics’, and in fact mean they do not get taught or learnt⁹²
- Use of assessment tasks that require English literacy for communication disadvantages some student population groups.⁹³

There were apparently opposing views about aspects of Queensland’s assessment system and their appropriateness for senior level mathematics, chemistry and physics:

- **School-based and external assessment** – and their respective validity and reliability
- **Assessment tasks** – extended investigations are seen to be too long and onerous, even while their use as a learning tool and for assessment may have been supported; and the style of presentation required (ie a written report format) is alleged to be biased against certain student groups (eg boys, those with limited literacy skills)
- **Number of assessment tasks** (ie continuous assessment) – is seen to be inappropriate, unnecessary and stressful
- **Numerical marking and standards-based assessment** – a very strong concern raised in submissions related to a perception that teachers are not allowed to use numeric marking. Using subjective descriptors is seen to be inappropriate for maths and science subjects, onerous for teachers, and leading to invalid, unreliable results.

⁸⁸ See for example, Submissions 105, 224 and 271

⁸⁹ See for example, Submission 30

⁹⁰ See for example, Submissions 162, 215 and 227

⁹¹ See for example, Submissions 14, 84 and 184

⁹² See for example, Submissions 117, 200, 277

⁹³ See for example, Submissions 21, 88 and 186

4.1 Who is raising concerns?

Submissions were received from teachers (by far the largest group of submitters), academics from the disciplines of mathematics, chemistry and physics and education; tertiary institutions, parents, students and recent students and a very small number of employers. As would be expected in an inquiry process, those who made submissions tended to be seeking a change to the status quo.

Submissions from parents were generally critical of the current system, raising issues such as the impact of current assessment processes on students' mental health, and the unnecessarily complexity of the standards-based assessment in mathematics and science subjects. The submissions from individual teachers, as well as teachers' unions and professional associations, varied in their focus. The submissions addressed school-based assessment, standards-based assessment and the use of numeric marking regimes, weighting, and extended assignments validity and usefulness as assessment tasks; and moderation processes. Many called for an external exam to assess some component of overall student achievement.

4.1.1 Whether assessment processes are supported by teachers

This part of the committee's terms of reference can be interpreted in several ways. It can be considered in terms of whether:

- teachers provide the practical support required for the system to operate (by implementing it and participating in it) or
- whether teachers personally like or dislike current assessment processes.

The committee believes both questions are important.

Mrs Walton, representing the QSA and perhaps focussing on the first interpretation of this term of reference, advised the committee as follows:

How do we know schools support the system? Teachers show their support for the system through their very representation on review panels. As I said earlier, there is currently a network of over 4,000 panellists performing this role. There are also healthy attendance figures at assessment workshops where syllabus requirements are discussed and resources provided to assist teachers in developing effective assessment tasks, and feedback received about the quality of these workshops is positive. Satisfaction with the syllabuses is consistently over 80 per cent in the annual survey of schools, even in the year following the introduction of the new physics and chemistry syllabuses.

Clearly, there are some people who would prefer an alternative to a system based solely on externally moderated school based assessment, but I suspect this is no different in other states and territories no matter what system is used, and differences of opinion are healthy. It encourages us to continually reflect on how we are doing assessment and examine its suitability and effectiveness for Queensland students.

Further, the submission from the QSA states that:

The Queensland system is based on a high level of participation and collaboration. The QSA has a number of representative committees that include

teachers and academics. These committees are closely involved in the development of QSA products, including syllabuses, and curriculum and assessment resources and policies.

The QSA board, its peak decision-making mechanism, includes teacher and union representatives, along with representatives of the schooling sectors, parents, higher education, and industry.

By far, the greatest support from teachers is demonstrated through their representation on review panels. The network of approximately 50 state and 400 district review panels covering the length and breadth of Queensland includes over 4000 experienced, registered teachers from State, Catholic and Independent schools.⁹⁴

To focus on the second interpretation, some submitters to the inquiry conducted analyses of the numbers of teachers who had submitted to the inquiry, and surmised from those numbers whether or not those teachers were in favour of or opposed to the current system.

As you can see ... 80 per cent to 90 per cent of teachers are very upset with this system and there is an enormous disconnect between the education theorists and the teachers practising at the coalface.⁹⁵

Dr Matthew Dean also stated:

[Eighty] per cent of submissions do want marks, tests and state exams in preference to the present system.

And asked:

May I, with respect, please point out that so far you have heard from many people in this process who support the system and yet there are 80 per cent of teachers and the general public who want change. Please make sure you listen to plenty of these people including Dr Stephen Norton, Anita Bailey, Brian Joy, Tempe Harvey and many others.⁹⁶

The committee received a large number of submissions in respect of this inquiry, the majority from individual teachers. The submissions demonstrate a significant effort to inform the committee, and the committee particularly thanks the authors. A significant number of 'form' letters were also received, and these were valued as collective expressions of opinion from those submitters. While the majority of the individual submissions called for change to the current system, they did not all call for wholesale change. Many had particular elements of the system they were concerned about, such as the lack of an external exam, the effect of EEs, the perceived inability to use numeric marks to grade a student's work, or a lack of focus on content knowledge. They were not all concerned about the same aspects.

It is important to note that key representative bodies including the Science Teachers' Association of Queensland, the Queensland Association of Mathematics Teachers; Brisbane

⁹⁴ Submission 129, QSA, p15

⁹⁵ Hansard, 22 May 2013, Dr Mathew Dean, p27, and tabled paper: www.parliament.qld.gov.au/documents/committees/EIC/2013/QldAssessment/tp-22May2013-Anderson2.pdf

⁹⁶ Ibid

Catholic Education and Independent Schools Queensland; the Queensland Teachers' Union and Queensland Independent Education Union; who all represent significant numbers of teachers or schools in Queensland, all indicated broad support for the current assessment methods and processes for senior mathematics, chemistry and physics. Like most submissions, they also indicated some areas for improvement.

Similarly, the submissions from tertiary education institutions were, with the exception of one, also broadly supportive of the current system. Individual discipline academics were fairly evenly divided in their broad support for the system, and education academics were all supportive.

There were very few, if any, submissions who considered that the system was perfect.

A public inquiry process is not the same as a voting process, and nor is it a survey. It was not designed to be either of those, and therefore it is not appropriate to use it in such a way. While we have considered 'ensuring assessment processes are supported by teachers', whether they are or not is not something about which the committee can make a definitive statement. There are too many variables for it to be appropriate to say that because a proportion of submissions express a position, this translates to the broader community. Broadly speaking, while noting the significance of the large number of submissions received, the committee has taken a qualitative approach to considering those submissions.

The submission process allows people to express their views, contribute to debate, and in doing so, engage in the public policy development process. Submissions are one of the sources of information that lead a committee to its conclusions.

Also relevant is who did not make submissions to this inquiry. A number of employer and industry-based organisations relevant to mathematics, physics and chemistry, were directly invited to make a submission, in the early stages of the inquiry. No industry groups responded within the three month timeframe for submissions, and so the committee was not made aware of there being any concerns on the part of those stakeholders about the terms of reference for this inquiry. The few employers who identified themselves as such were mainly small business owners and in the main, they were interested in being able to understand what students can do based on their senior certificates, and want to be able to trust that senior graduates have a basic understanding of key mathematical and scientific concepts. They did not feel this occurred at present.⁹⁷

What the committee's research has found, though, is that if the AIG are indicative of industry views, then industry would seem to support the type of approach to teaching and learning, if not explicitly to assessment, that is a feature of Australian and Queensland curricula for these subjects.⁹⁸

⁹⁷ Submission 73, 114

⁹⁸ AIG

5 Student participation: the data

5.1 Student participation

Diverse views were presented to the committee about whether participation in mathematics, chemistry and physics is increasing, remaining constant or declining, and whether any changes in participation rates are linked to the senior assessment methods for these subjects. This section analyses the views presented to the committee, examines objective data on participation levels in these subjects in Queensland and compares this information to other jurisdictions, Australia as a whole and internationally. Participation levels by gender are analysed, in addition to factors that may affect participation rates. This section considers whether participation levels are linked to assessment methods in senior mathematics, chemistry and physics in Queensland schools.

5.1.1 Views of inquiry participants

‘Participation levels have decreased’

Some inquiry participants expressed concern that student participation in mathematics, chemistry and physics is declining. Professor Renshaw observed that this is a concern at school and university level, “[h]owever, the reasons affecting student participation in these subjects are complex and need to be addressed in strategic ways.”⁹⁹ Dr Ridd also believes that participation levels have decreased.¹⁰⁰ A chemistry teacher noted that “[w]orkloads have increased dramatically, students are not coping and are having breakdowns, students choose subjects other than science, because they are easier.”¹⁰¹

A senior physics teacher told the committee that “[t]he introduction of the 2007 senior physics syllabus has not addressed the decline in the participation rate or the increasing drop-out rate.”¹⁰²

This chapter considers QSA data to determine whether participation levels have decreased in senior mathematics, chemistry and physics.

‘Participation levels have decreased because of assessment methods’

The impact of assessment methods on student participation in mathematics, chemistry and physics was raised as a concern in a number of submissions.¹⁰³ Some inquiry participants believe that current assessment methods deter students from studying these subjects. For example, a mathematics and physics teacher, who is also a panellist, told the committee “I would think that there is little about the current syllabi and assessment processes that would encourage greater participation in mathematics and the physical sciences.”¹⁰⁴ The parent of a 2012 Year 12 student also considers that current assessment methods, such as extended research assignments and the lack of marks and percentages, discourage student participation.¹⁰⁵

⁹⁹ Professor Peter Renshaw, Head of School of Education, University of Queensland, Submission 224, p2

¹⁰⁰ Dr John Ridd, Submission 105, p6

¹⁰¹ Name suppressed, Submission 271, p1

¹⁰² Public hearing transcript, Education and Innovation Committee, 10 July 2013, p6

¹⁰³ See for example, Submissions 163, 170 and 253

¹⁰⁴ Name suppressed, Submission 163, p1

¹⁰⁵ Ms Lea McCulloch Submission 277, p1

Reasons why assessment methods may impact student participation were provided by a teacher of senior mathematics, who is also a former head of department and panellist. He observed that participation levels will drop if you “... (i) design assessment tasks that are inordinately long, time consuming and with questionable relevance, and (ii) design assessment criteria that are not transparent.”¹⁰⁶ A teacher of senior mathematics and physics, who is also a parent of a student who studied mathematics, chemistry and physics, noted the time spent on assessments such as assignments and EEs and ERTs, “... [w]e have students coming in at lunch times, after school and whole days on weekends to complete the assessment pieces.”¹⁰⁷

A science co-ordinator, who is also a physics and chemistry teacher, considers that “... Year 11 enrolments are probably a little lower under these syllabi. However, I have certainly observed a greater rate of students dropping out of the subjects.”¹⁰⁸

‘Participation levels have decreased, but not because of assessment methods’

A number of inquiry participants consider that participation rates in mathematics, chemistry and physics subjects have decreased, but that this cannot be attributed to current assessment methods.¹⁰⁹

The Queensland Studies Authority referred to a number of reports that “[o]ver the last two decades, enrolments in senior mathematics and science subjects in all jurisdictions in Australia have been declining” and consider there is no single cause.¹¹⁰

Brisbane Catholic Education acknowledged the decline in participation in mathematics and science over the last thirty years, while noting “... there is no evidence that the introduction of new syllabuses and alternative assessment methods from around 2005 can be identified as a cause for lower student participation rates in Mathematics and Science at either senior schooling or tertiary levels ...”¹¹¹ Similarly, a maths teacher and panellist considers “[t]here is no evidence to suggest that the current assessment practices have impacted on student participation levels [in senior mathematics].”¹¹²

A head of department, who is also a state monitoring panel chair, notes the decline in participation in ‘higher level subjects’, while noting that many factors influence this including recent flood events. He stated that “... sadly the numbers of students choosing the higher level subjects continue to slowly subside at my school. This year for the first time I have now had to teach a combined year 11 / 12 Physics class because of the drop in numbers.”¹¹³

‘Participation levels have not decreased’

Brisbane Catholic Education advised that the percentage of OP eligible students [studying under BCE?] electing to study mathematics, physics and chemistry has remained constant from 2000-2012 “... despite the introduction of new syllabus documents (and alternative

¹⁰⁶ Mr Steve Crapnell, Submission 100, p2

¹⁰⁷ Name suppressed, Submission 230, p2

¹⁰⁸ Mr Neil Daly, Submission 170, p1

¹⁰⁹ See for example Submissions 129 and 149

¹¹⁰ Queensland Studies Authority, Submission 129, p23

¹¹¹ Brisbane Catholic Education, Submission 149, p4

¹¹² Mr Michael Barra, Submission 248, P3

¹¹³ Mr David Austin, Submission 11, p2

assessment methods) during this period and a significant push to cater for the broader range of students seeking alternative pathways into post school employment and training.”¹¹⁴

Some teachers also expressed the view that mathematics, chemistry and physics participation rates are not decreasing, and in some subjects are in fact increasing:

*Talking to other teachers at Mathematics C panel meetings, the anecdotal evidence seems to be that Mathematics C is experiencing a growth in numbers. Possibly this has to do with the mining boom and the fact that many students see Engineering and the Sciences as good career prospects.*¹¹⁵

‘Many factors influence student subject decisions’

A physics teacher, who is also a panellist, considers there are many reasons why students choose to participate in a subject and that variation in participation rates should not be attributed solely to assessment methods:

*Students choose their senior subjects in Term 4 of Year 10. While there may be some who are discouraged by the excessive workload imposed by the assessment methods, most choose Mathematics, Physics and Chemistry because: 1. They like the subject or they enjoyed it in Year 10. 2. It is a prerequisite for their intended university course or it will help them in their university course. 3. Their career advisor, teacher, parents or siblings suggested they do it. 4. It will improve their OP score. 5. They like the teacher teaching the subject. 6. They have had positive input from students who are currently studying the subject. 7. They want to try it for a semester and see. 8. They like less the alternative subjects offered on that line. 9. Their friends are doing it.*¹¹⁶

Other teachers expressed, “I don’t think the assessment methods have a great influence on the subjects chosen in senior Mathematics”¹¹⁷ and “By and large, I do not think assessment has had any influence on the participation level of students in senior maths”.¹¹⁸

A teacher of senior chemistry and mathematics told the committee:

*I cannot state it categorically but I am quite certain that very few students consider the syllabus or the assessment plan when they are making their decision to do chemistry or, for that matter, physics or maths. I can only conclude that there is very little evidence to support the tenet that syllabus or the assessment have resulted in lower participation rates around Queensland.*¹¹⁹

A teacher of senior science, who is also a former scientist, also identified a range of factors that influence a student’s subject decision:

... the primary factors influencing senior subject selection by students are their future career choices and tertiary prerequisites, their ability in subjects,

¹¹⁴ Brisbane Catholic Education, Submission 149, p4

¹¹⁵ Mr Steve Ryan, Submission 43, p3

¹¹⁶ Name suppressed, Submission 51, p3

¹¹⁷ Mr Steve Ryan, Submission 43, p3

¹¹⁸ Public hearing transcript, Education and Innovation Committee, 10 July 2013, p13

¹¹⁹ Public hearing transcript, Education and Innovation Committee, 22 May 2013, p16

*workload and intrinsic interest and enjoyment they gained from studying them in their junior years.*¹²⁰

‘The new syllabus did not address declining participation’

Dr Arnison, a former school principal and mathematics, chemistry and physics teacher, who also holds research degrees in education (Doctor of Philosophy) and chemistry and physics (Master of Philosophy) and who served as a QSA and Queensland Curriculum, Assessment and Reporting (QCAR) board member, observed that the syllabus introduced in 2005-2006 did not improve participation levels as anticipated:

*QSA has advocated a ‘constructivist view of education’ where pupils are encouraged to construct their own meaning for phenomena they encounter in their world. QSA predicted that this would be more engaging for pupils and that it would raise participation rates in mathematics and science. However, there is no evidence from the participation rates tabled before the Inquiry that participation rates in Chemistry, Physics and Mathematics that participation rates have improved. In fact since these methods were given increased emphasis in the 2005-2006 syllabuses participation rates in these subjects have remained stable or declined slightly.*¹²¹

A teacher of senior physics, who is also a former head of department and panellist, noted that participation levels in physics have not increased in 20 years, although the 2007 introduction of the syllabus was meant to address this issue:

*The Queensland Studies Authority (QSA) Year 12 physics enrolment data between 1992 and 2012 ... indicates that enrolments in 1992 were 7,281 and 7,155 in 2012, no marked change. I have had discussion with physics teachers that participated in the Extended Trial Project who noted that the introduction of the new 2007 senior Physics syllabus was supposed to address the major concerns about falling enrolments in senior physics. Clearly this has not been the desired outcome as the enrolment numbers have not shown any marked change over the last twenty years.*¹²²

Dr John Ridd PhD, a tutor and a former teacher, who was the head of a number of mathematics departments, a district panel chair and co-authored of a series of mathematics text books, agrees that the new syllabi did not increase student participation.¹²³ Mr Hughes, a mathematics teacher and panellist also notes that “... participation levels, if an issue at all, are not the result of changes in the 2008 syllabi.”¹²⁴

Refer to section 3.2.1 for current syllabus implementation dates.

¹²⁰ Name suppressed, Submission 121, p38

¹²¹ Dr B. J. Arnison OAM, Submission 228, p20

¹²² Mr Paul Evans, Submission 253, p6

¹²³ Dr John Ridd, Submission 105, p6

¹²⁴ Mr Matthew Hughes, Submission 13, p1

5.1.2 What does the data and research show?

Queensland (QSA data on student participation)¹²⁵

Enrolments

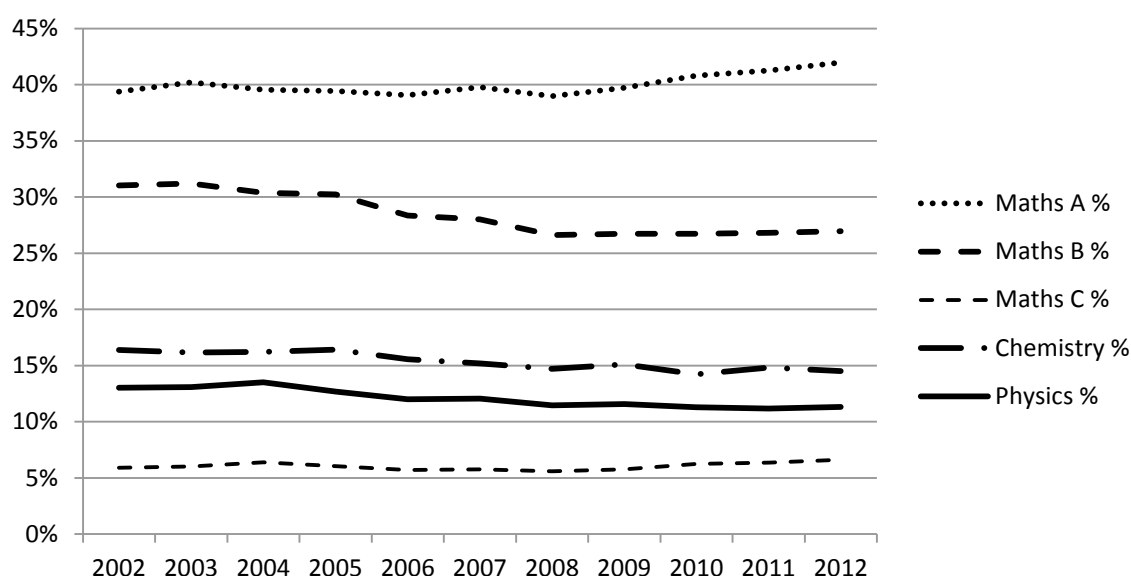
Over the last decade, enrolments in mathematics A, B, C, chemistry and physics in Queensland schools did not increase at the same rate as the student population. Year 12 enrolments as a proportion of the weighted population decreased in mathematics B from 31% in 2002 to 27% in 2012, from 16% to 15% in chemistry and from 13% to 11% in physics, as illustrated in Figure 1. Enrolments increased from 39% to 42% for mathematics A and from 6% to 7% for mathematics C over the same period. The weighted population increased by 20% over the same period.

Year 12 enrolment figures have been compared to the weighted population, which is a weighted average of the age distribution of the Year 12 population.

Mr Paul Evans, a teacher of senior physics, who is also a former head of a physics departments and district panel member, analysed QSA data and told the committee that:

*... despite the population increase in Queensland and the number of schools increasing from 290 in 1992 to 386 in 2012, the enrolment numbers in senior physics have stayed constant for the last 20 years.*¹²⁶

Figure 1: Year 12 enrolments as a proportion of the weighted population



There was a decrease in the proportion of students enrolled in mathematics B over the decade, while the proportion of enrolled in mathematics A increased over this period. This shift from advanced to intermediate to elementary might be expected, because of government policy changes in 2006 which required Queensland students to remain in fulltime education until the age of 17, unless they were in fulltime employment.

¹²⁵ Queensland Studies Authority, www.qsa.qld.edu.au/617.html <site accessed 3 September 2013> and weighted population data provided upon committee request

¹²⁶ Public hearing transcript, Mr Paul Evans, 10 July 2013, p6

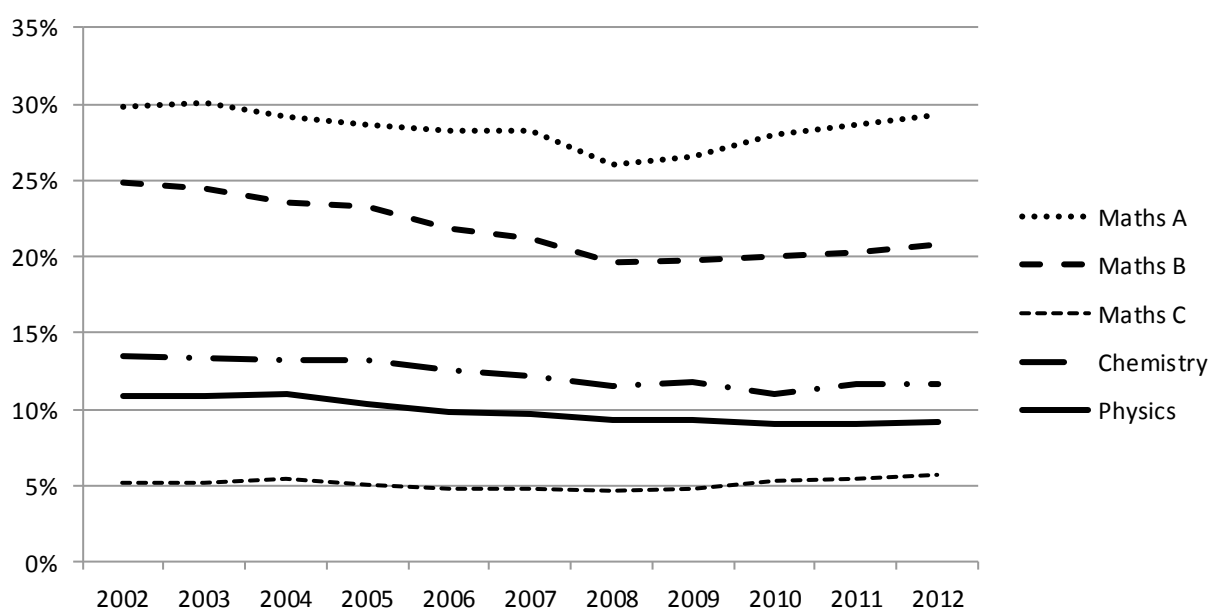
Consequently, retention rates increased, as did enrolments in vocational education subjects and the more foundational mathematics A.

There has been a significant increase in the number of subject options available to students over the past decade, which may also partly account for the fact that enrolment in these subjects has not increased at the same rate as the population.

Completion rate

The proportion of students who completed senior mathematics, chemistry and physics also generally decreased over the decade, except for mathematics C in which a small increase (approximately 1%) in the proportion of students completing the subject was observed. Students are considered to have completed a subject once they have completed four units of study, that is, two units in Year 11 and two units in Year 12. The completion rate is determined by dividing the number of completions for each subject by the total weighted population. The largest decrease in student completions was observed in mathematics B, falling from 25% in 2002 to 21% in 2012. Chemistry completions decreased from 13% to 12%, physics from 11% to 9% and mathematics A from 30% to 29%.

Figure 2: Year 12 student completion rates



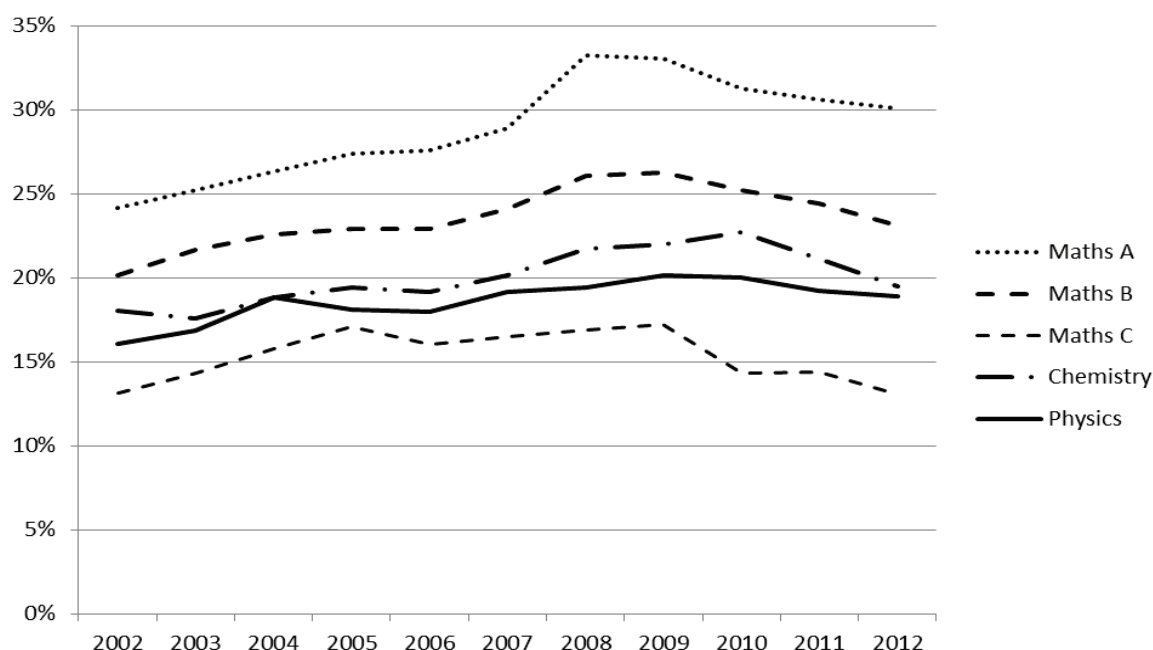
Drop-out rate

While the participation rate and completion rate has generally decreased from 2002-2012, the drop-out rate has increased for all subjects except mathematics C. The drop-out rate for this subject fluctuated over the decade but decreased from 2008 and was the same in 2012 as it was in 2002 (13%). This subject has the lowest drop-out rate of the subjects that are the focus of this inquiry. The drop-out rate is calculated by dividing the difference between the number of year 12 enrolments and the number of completions by the number of year 12 enrolments. The highest drop-out rate, and largest increase in this rate, was observed in mathematics A, which increased from 24% in 2002 to 30% in 2012. Other subjects increased from 0% (mathematics C) to 3% (mathematics B and physics).

The data, which shows that enrolments in mathematics C have increased and the drop-out rate has remained relatively constant, is supported by evidence received from inquiry participants. A mathematics head of department told the committee *"... this year I have 23 students in my year 11 maths C class, which is a record for our school. In talking to other people at panel, there seems to be a resurgence in students doing maths C."*¹²⁷

Possible reasons for an increasing student drop-out rate in mathematics, chemistry and physics are complex, and further analysis of the participation in all subjects would be required to fully appreciate the changing nature of student participation in senior subjects. This is outside the scope of this inquiry. The committee understands that it may be in the best interests of some students to change subjects in order to achieve a higher final result. Students consider where their effort will result in the best overall result when choosing subjects, and when deciding whether to move subjects. For example, a student may determine that it is advantageous for their final result to achieve a sound achievement in a subject they find easier, and therefore move to a less demanding subject. This is also affected by rules and policies that govern senior certification.

Figure 3: Drop-out rate of Year 12 students



Many initiatives are underway nationally and within Queensland to try to increase participation in mathematics and science subjects, including the Diamantina Institute at the University of Queensland which was established to work with schools on science education, and also supports a range of industry – school partnerships. A feature common to many of these initiatives is a focus on inquiry as a means of engaging students. This reflects the current approach to teaching and learning in Queensland, and in Australia generally.

University participation

Similar to the pattern of participation in mathematics, chemistry and physics at school, there has been a decline in the proportion of students studying these subjects at Australian

¹²⁷ Public hearing transcript, Education and Innovation Committee, 10 July 2013, p13

universities. Although the number of students studying science subjects at university level increased by 22% from 1989 to 2005, the number of students studying mathematics decreased by 2,532 students (34%), chemistry decreased by 315 students (5%) and physics decreased by 701 (19%) over the same period.¹²⁸ The overall increase in the number of students studying science is attributed to a significant increase in the number of students studying biological sciences and other sciences.

Australia

Participation in mathematics and science in Year 12 across Australia has decreased for more than two decades and continues to fall slowly. Between 1992 (after which time school retention rates were fairly stable) and 2009, the proportion of Year 12 students studying physics, chemistry and biology fell by 31 per cent, 23 per cent and 32 per cent respectively.¹²⁹

There were 153,512 students studying mathematics in Year 12 in Australia in 2010 (72% of the cohort) although the raw numbers tell just part of the story. There has been a shift from 'advanced' and 'intermediate' to the 'elementary'.¹³⁰

In 2010 there were only 62,000 Year 12 students taking advanced and intermediate mathematics in Australia. These are requirements for some university courses, though that has changed as well as in university entrance policies have responded to broader national education policy changes, such as university funding arrangements and the uncapping of places.

With regard to participation in mathematics across jurisdictions, the Australian Council for Educational Research (ACER) reported a decline in participation in advanced mathematics subjects across most Australian jurisdictions from 1991-2000, while noting:

*It is difficult to compare mathematics participation across jurisdictions in subjects that may differ widely and caution should be exercised interpreting trend analyses because of changes to mathematics curricula over time.*¹³¹

International

Many Organisation for Economic Cooperation and Development (OECD) countries have experienced a decline in the percentage of students studying science, technology, engineering and mathematics (STEM subjects) over the past 20 years.¹³²

A teacher, who is also a panellist and district panel chair, observed:

... the downward trend in enrolments in these [mathematics, chemistry and physics] or similar subjects has been well documented throughout Australia, France, Germany, United Kingdom, New Zealand and Canada over the last two decades. Several reports prepared by UNESCO in the last five years have

¹²⁸ Dobson, Ian (2007) *Sustaining science: University science in the twenty-first century*, Australian Council of Deans of Science, p71

¹²⁹ Australia. Office of the Chief Scientist, [Mathematics, Engineering and Science in the national interest](#) May 2012 p19

¹³⁰ Ibid

¹³¹ Australian Council for Educational Research (2008), *Participation in science, mathematics and technology in Australian education*, p24-25

¹³² Organisation for Economic Cooperation and Development, *Evolution of student interest in science and technology studies: Policy report*, OECD Global Science Forum

identified falling enrolments in science and higher mathematics as a serious problem, as have the Australian Council of Deans of Science in an occasional paper “Who’s Teaching Science”.¹³³

As described in this chapter, a similar pattern is observed in the decreasing participation rate in mathematics, chemistry and physics in Queensland. As this pattern is not unique to Queensland, it is likely there are many factors, both locally and internationally, that influence participation in the STEM subjects that are the focus of this inquiry.

5.1.3 Participation by gender

An issue raised by some inquiry participants relates to a perceived decline in the proportion of male students studying science. Participation rates in mathematics, chemistry and physics have been analysed by gender over the last 10 years and are discussed in this section.

At a public hearing, a chemistry teacher told the committee:

I often come across boys who are exceptionally good at maths and science but when it comes to writing they have never been as good. I do believe that having an emphasis on the literary parts of science does discriminate against boys.¹³⁴

A mathematics teacher considers that male students choose to leave subjects due to the “... amount of documentation and word lengths associated with these [EELs and ERTs] assessment types.”¹³⁵ A decrease in the participation of male students in senior chemistry and biology have been observed by a teacher who noted:

[i]n my school, girls outnumber boys by a clear majority in Chemistry and by a vast majority in Biology. Boys seem to find it harder to engage with and succeed at the current assessment strategies because they emphasise project work, long written texts, and interpretive methods for determining achievement.¹³⁶

The written component of chemistry assessment is also considered to have affected the gender balance at another school:

The number of girls in my Chemistry classes is about 50% greater than the number of boys. In my opinion the reasons why this has occurred include the following ... In general, the increase in extended writing requirements of the current syllabus favours girls over boys.¹³⁷

A mathematics and physics teacher, who is also a panellist, refers to the ‘feminisation’ of assessment and notes that although this “... might encourage greater participation of girls and might discourage boys ... from my discussions with students over my teaching career other factors are more important.”¹³⁸

¹³³ Mr Andrew Findlay, Submission 136, p2

¹³⁴ Ms Maureen Anderson, public hearing transcript, 22 May 2013, p12

¹³⁵ Mr Cameron Ross, Submission 25, p1

¹³⁶ Name suppressed, Submission 184, p1

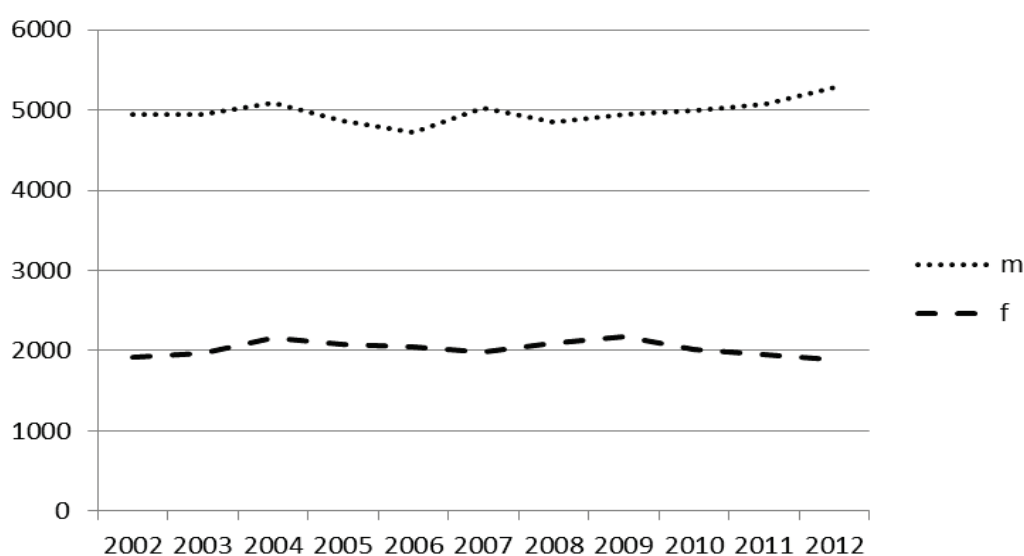
¹³⁷ Name suppressed, Submission 152, p1

¹³⁸ Name suppressed, Submission 163, p1

Physics data

The number of Year 12 male students enrolled in physics in Queensland increased from 4,856 students in 2008 to 5,275 in 2012, whereas from 2009 female participation decreased from 2,091 students to 1,879 students, as illustrated in Figure 4.¹³⁹ Over the decade, male student enrolments increased by 337 students (7%) and female enrolments decreased by 44 students (2%).

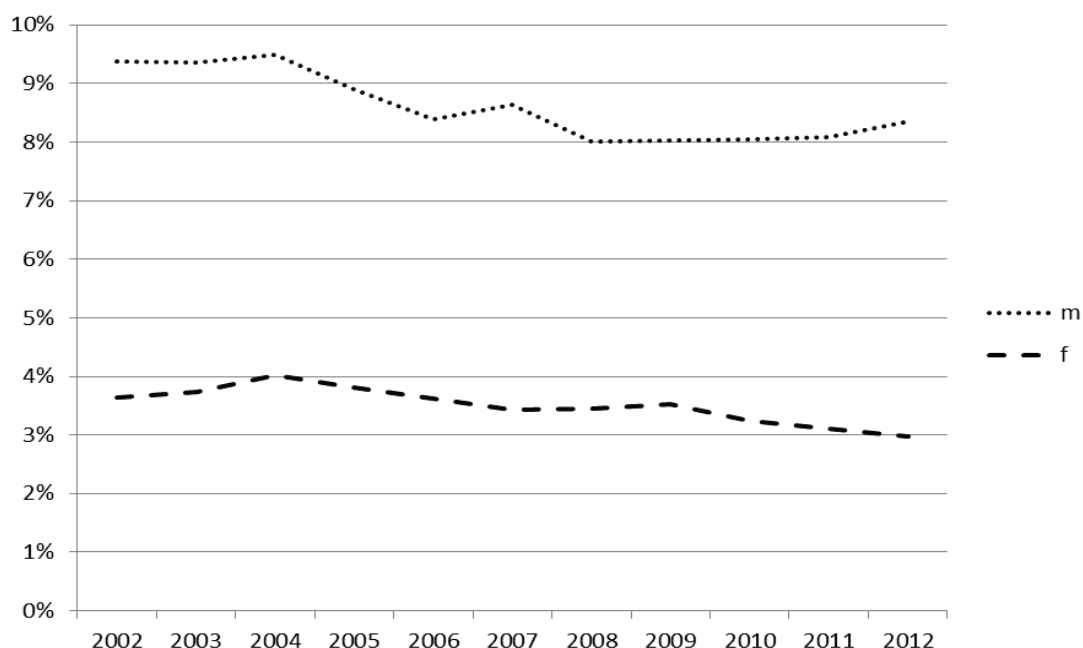
Figure 4: Number of Year 12 students enrolled in physics, by gender



As a proportion of the weighted population, the percentage of male students studying physics has generally decreased from 9% in 2002 to 8% in 2012. The percentage of females studying physics over this period also decreased, from 4% to 3%, as illustrated in Figure 5.

¹³⁹ Queensland Studies Authority, www.qsa.qld.edu.au/617.html <site accessed 3 September 2013>

Figure 5: Year 12 participation in physics as a percentage of the weighted population, by gender



When comparing the participation of Queensland students in physics to that in other states, it appears there are a significantly higher percentage of males studying physics in all states. There was a higher percentage of female students studying physics in Queensland in 2012 (26% of physics students)¹⁴⁰ than in Victoria (21%)¹⁴¹ and New South Wales (22%).¹⁴²

Chemistry data

In-line with anecdotal evidence provided to the committee, the number of female students studying chemistry has generally increased. From 2002 to 2012, the number of female students enrolled in chemistry increased by 535 enrolments (13% of female enrolments), while the number of male enrolments increased by only 108 enrolments (2% of male enrolments) over the same period. Both male and female enrolments decreased at times, however, overall increased.

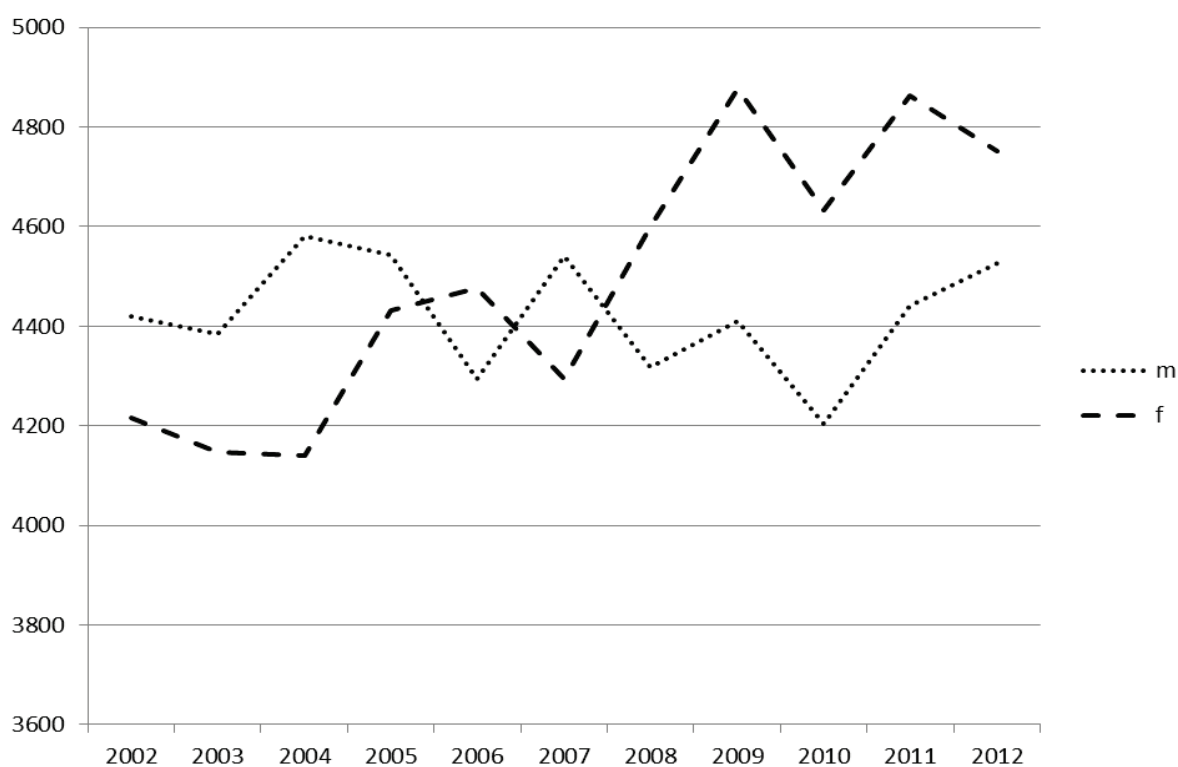
The number of female students studying chemistry has been increasing since 2007. Female participation overtook the number of males enrolled in chemistry in 2006, decreased in 2007, then overtook male participation again from 2008 to 2012.

Chemistry and mathematics A are the only subjects in scope for this inquiry where female participation exceeds male participation both in the number of enrolments and as a proportion of the weighted population.

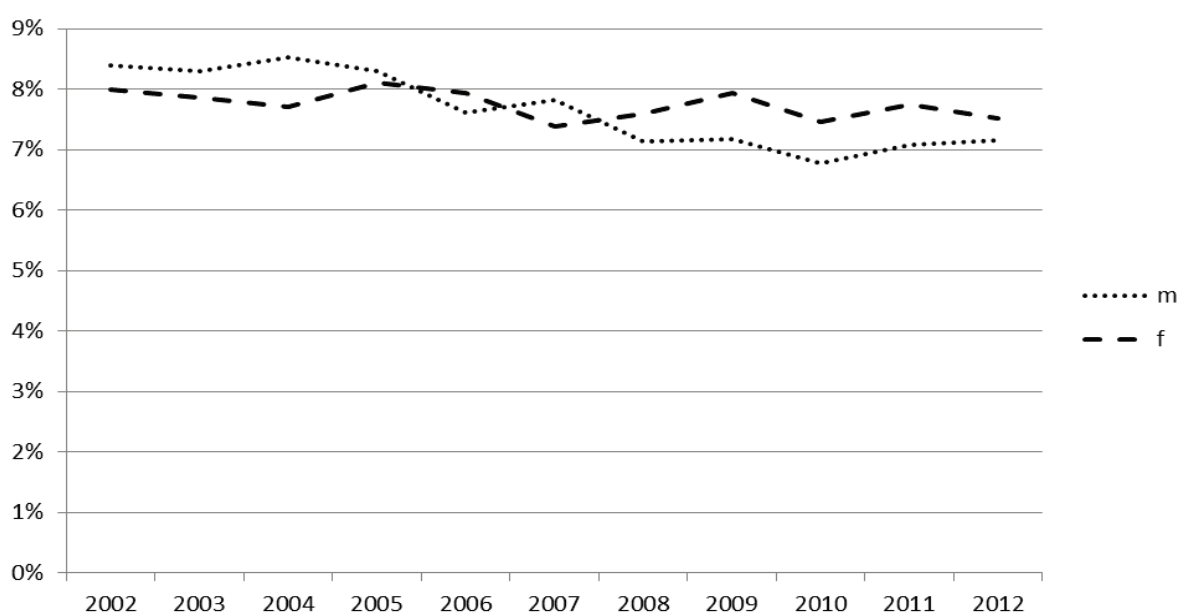
¹⁴⁰ QSA, Submission 129, p23

¹⁴¹ Ibid

¹⁴² NSW Board of Studies www.boardofstudies.nsw.edu.au/ebos/static/EN_SX_2012_12.html

Figure 6: Number of Year 12 students enrolled in chemistry, by gender

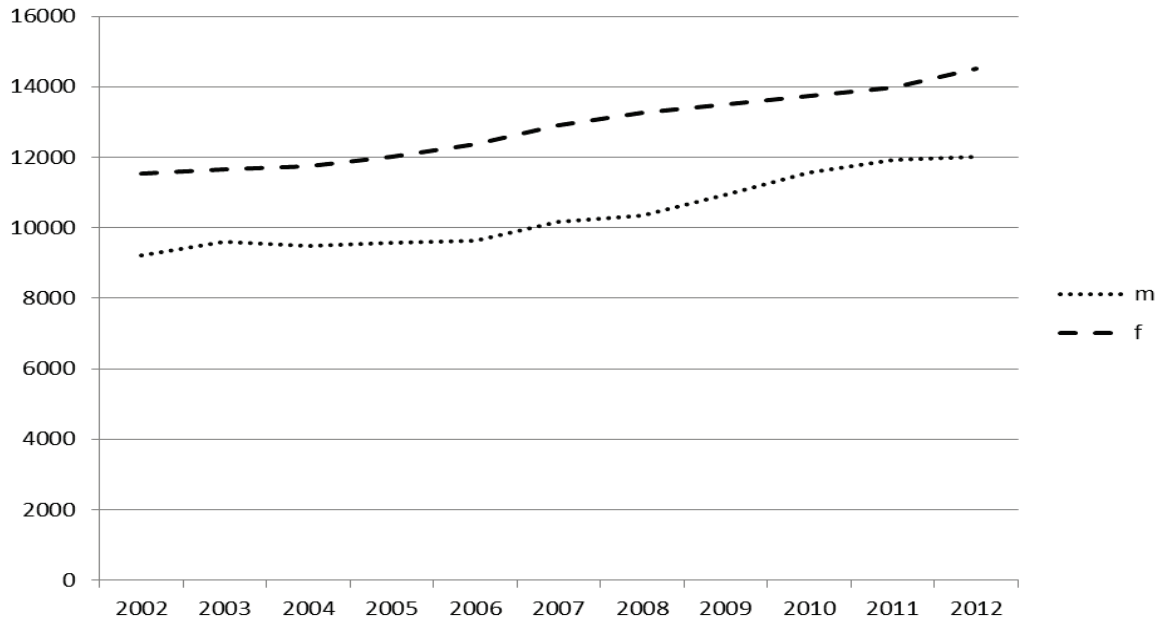
As a percentage of the weighted population, the proportion of males studying chemistry has decreased from 8% to 7% since 2002, as illustrated in Figure 6. The proportion of females studying chemistry has remained relatively stable at 8%, dropping to 7% in 2007 and 2010.

Figure 7: Year 12 participation in chemistry as a percentage of the weighted population, by gender

Mathematics A data

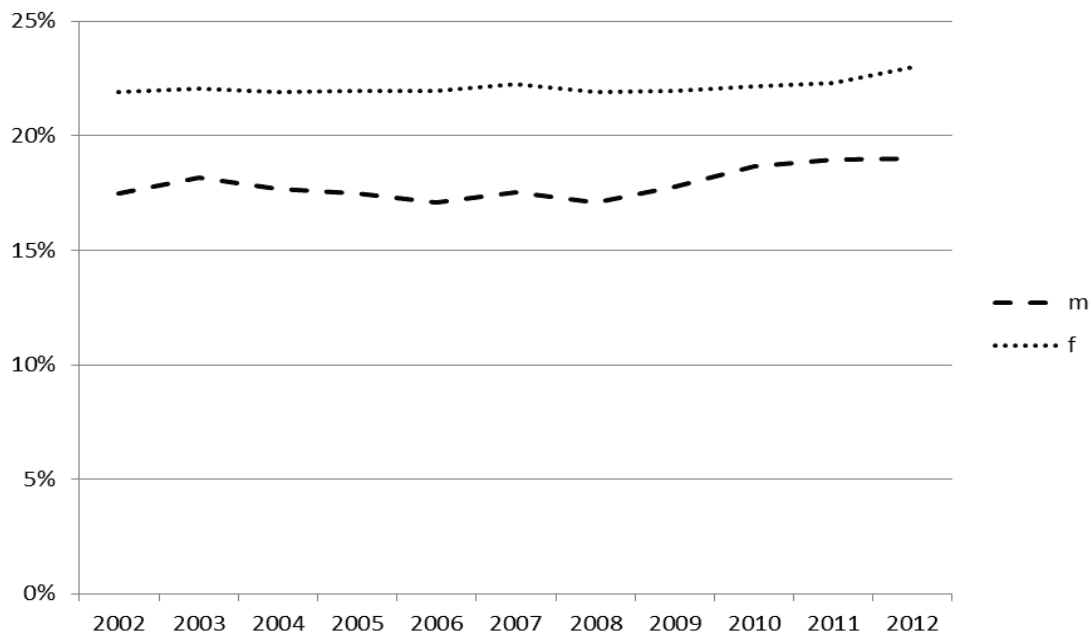
The number of male and female students enrolled in mathematics A increased from 2002 to 2012. The number of females enrolled in mathematics A increased by 26% from 2002-2012, while the number of males increased by 30%.

Figure 8: Number of Year 12 students enrolled in mathematics A, by gender



Enrolments in mathematics A as a proportion of the weighted population increased from 39% to 42% from 2002 to 2012, as illustrated in Figure 8. This represents the largest increase in participation when compared to the remaining subjects that are the focus of this inquiry.

Figure 9: Year 12 participation in mathematics A as a percentage of the weighted population, by gender



Mathematics B data

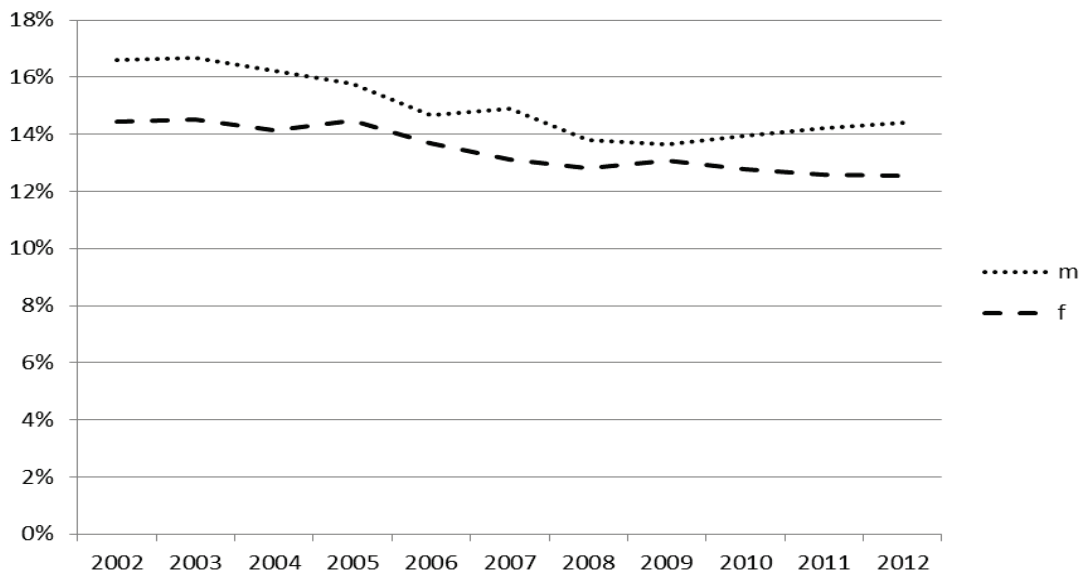
The number of male and female students enrolled in mathematics B generally increased from 2002 to 2012, although it dipped at times (figure 10). The number of students enrolled in mathematics B increased by 4% for both male and female students. A larger number of male students than female students were enrolled in mathematics B every year from 2002 to 2012. Since 2009, the number of male enrolments has increased, whereas the opposite is generally true for female enrolment. Female enrolments decreased from 2009 to 2011, with a small increase was observed in 2012.

Figure 10: Number of Year 12 students enrolled in mathematics B, by gender



Both male and female enrolments in mathematics B have decreased as a proportion of the weighted population since 2002. Male enrolments decreased from 17% in 2002 to 14% in 2012, while female enrolments decreased from 14% to 13% over the same period. This is illustrated in Figure 10.

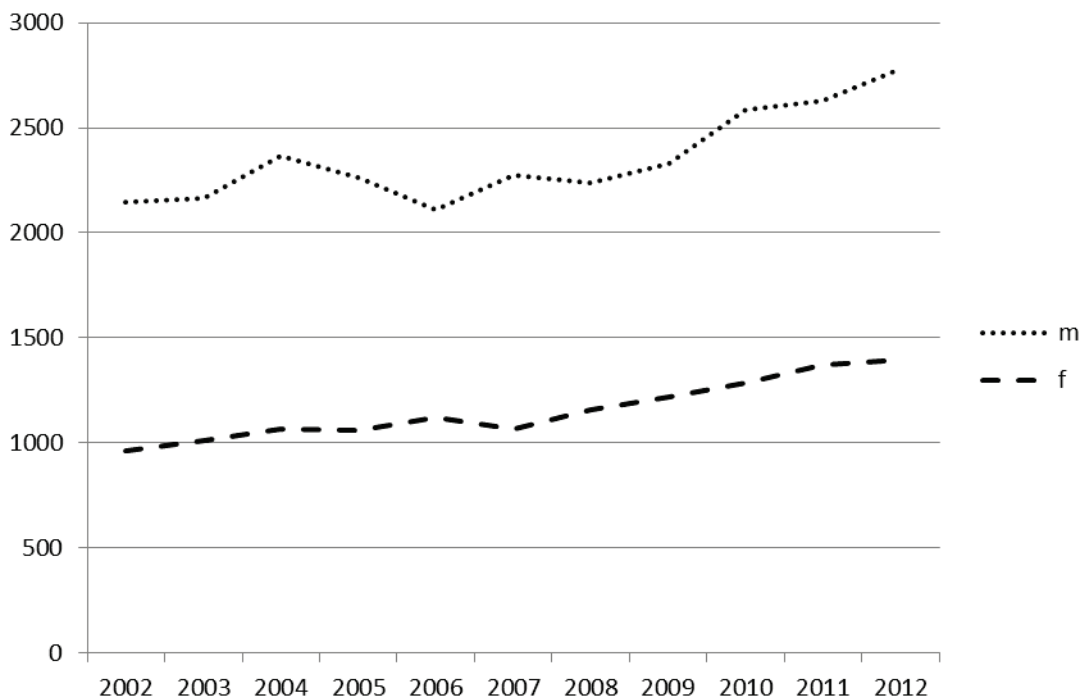
Figure 11: Year 12 participation in mathematics B as a percentage of the weighted population, by gender



Mathematics C data

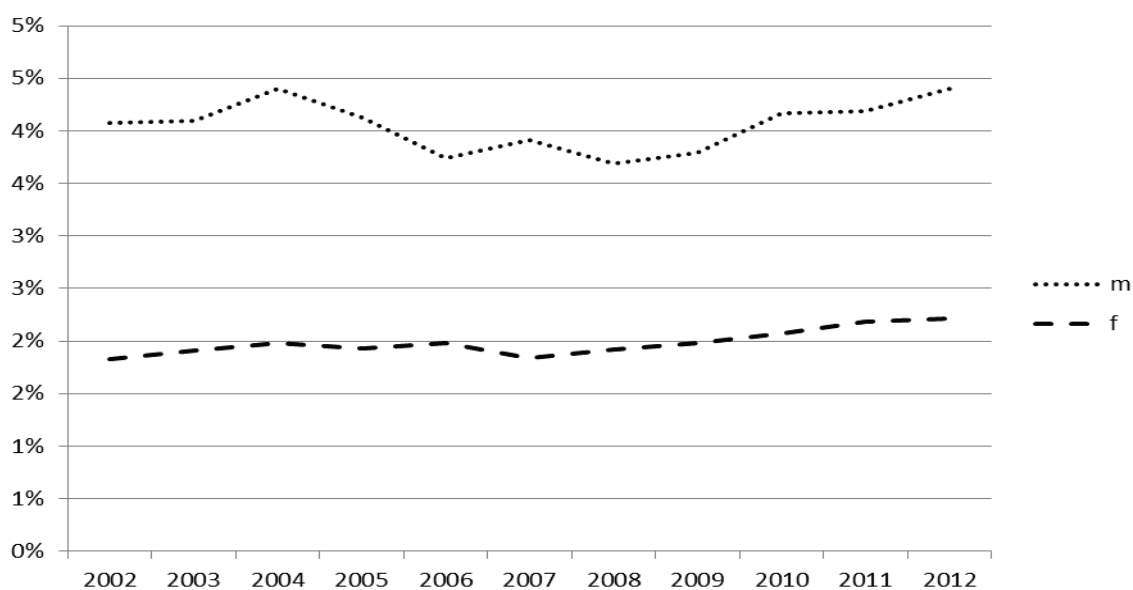
The number of male and female students enrolled in mathematics C increased from 2002 to 2012, although dipped at times. The number of male students increased by 30%, while the number of female students increased by 45% over this period. Since 2002 there have been approximately twice as many male enrolments each year than female enrolments.

Figure 12: Number of Year 12 students enrolled in mathematics C, by gender



As a proportion of the weighted population, participation in mathematics C has remained relatively constant at 4% for male students and 2% for female students, as illustrated in Figure 13.

Figure 13: Year 12 participation in mathematics C as a percentage of the weighted population, by gender



5.1.4 What affects participation rates?

Learning experience and achievement in early years

Research has found a strong association between learning experience and achievement in mathematics in earlier years and studying physics or chemistry in Year 12. Research conducted by ACER noted:

*The experience of science and mathematics learning in primary and lower secondary school is relevant to a consideration of participation in science, technology, engineering and mathematics. Those experiences can establish the sense of competence that students have in the foundations of mathematics and science and can kindle their interest in science-related fields.*¹⁴³

Research completed as part of the Longitudinal Surveys of Australian Youth found a strong correlation between performance in earlier school years with achievement in the final year of school. It observed a “... strong relationship between Year 9 achievement and tertiary entrance performance ... students in the highest Year 9 achievement quartile having the highest median ENTER [Equivalent National Tertiary Entrance Rank] score, and students in the lowest Year 9 achievement quartile having the lowest median ENTER score.”¹⁴⁴

Socioeconomic background

Research conducted by ACER found a strong association between socioeconomic background and studying chemistry or physics: “[t]he participation rate in chemistry and physics among Year 12 students from the highest four socioeconomic groups was almost twice that of students from the lowest socioeconomic group.”¹⁴⁵

The Parliament of Victoria’s Education and Training Committee also observed a correlation between a student’s socioeconomic background and participation in science and mathematics subjects:

*Students from higher socioeconomic backgrounds have significantly greater levels of participation and achievement in the highest level mathematics and science subjects, compared with students from lower socioeconomic backgrounds.*¹⁴⁶

The influence of socioeconomic issues on subject participation and student choices is a complex and multifaceted issue. It was not considered to be within the scope of the inquiry, or within the time available, to consider these issues in detail.

¹⁴³ Australian Council for Educational Research (2008), *Participation in science, mathematics and technology in Australian education*, p3

¹⁴⁴ Gary N. Marks, Julie McMillan, Kylie Hillman (2001) ACER, *Tertiary Entrance Performance: The role of student background and school factors*, Research Report 22, p13

¹⁴⁵ Australian Council for Educational Research (2008), *Participation in science, mathematics and technology in Australian education*, p23

¹⁴⁶ The Parliament of Victoria, Education and Training Committee, *Inquiry into the Promotion of Mathematics and Science Education*, p155

University prerequisites

The influence of university course prerequisites on students' decisions to study science at school was considered in a former Queensland Government discussion paper on STEM skills. It was noted that when science subjects changed from being prerequisites for science-based courses at university to assumed knowledge, enrolments in school science courses began to decline. In addition, the discussion paper referred to a submission to an Australian Government audit into STEM skills as advising that *"[s]tudents can be accepted into science-based courses at university without having studied science at school, provided that their tertiary entrance score is sufficiently high."*¹⁴⁷

The Commonwealth Office of the Chief Scientist also acknowledged that a number of universities have relaxed the requirements for students to complete senior physics, chemistry and some mathematics subjects, which has reduced their strategic value.¹⁴⁸

Inquiry participants identified a possible link between university requirements and students' decisions to study science at university.¹⁴⁹ With reference to physics, a teacher of senior physics, who is also a head of department and panellist, wondered whether there is *"... too much risk (including time commitment) to take a subject that has a reputation for being challenging and is not a prerequisite for any University course in Australia – only a recommendation!"*¹⁵⁰ With regard to physics, the Queensland Studies Authority noted that *"Relaxed university pre-requisite requirements has meant that it is possible for a student to enrol in a Bachelor of Engineering course, for example, without having studied Physics in Years 11 and 12."*¹⁵¹

A teacher and panellist told the committee that students often choose the more challenging subjects such as mathematics B and chemistry, because they are prerequisites and that:

*... "good" performance in these subjects will help improve their OP. If greater participation is desired the easy option is for universities to make Physics and Maths C prerequisites again. As soon as the University of Queensland dropped Maths C from their engineering/science prerequisites the other Queensland universities followed and the Maths C enrolments dropped as students felt they didn't need them and logically choose other options."*¹⁵²

Perceptions

A 2006 study found that teaching and assessment processes had much less to do with subject choice than did the perceptions about what post-school options these subjects might lead to; and the students' family, cultural and social characteristics. The study found that *"[m]any of the students regarded junior high school science as irrelevant, uninteresting and difficult, leaving them with few intrinsic reasons for enrolling in senior science courses."*¹⁵³

¹⁴⁷ Queensland Government, Towards a 10-year plan for science, technology, engineering and mathematics (STEM) education and skills in Queensland, discussion paper, p17

¹⁴⁸ Office of the Chief Scientist (2012) *Mathematics, engineering and science in the national interest*, p9

¹⁴⁹ See for example Submissions 13 and 253

¹⁵⁰ Mr Paul Evans, Submission 253, p9

¹⁵¹ Queensland Studies Authority, Submission 129, p23

¹⁵² Name suppressed, Submission 163, pp1-2

¹⁵³ Lyons, Terry (2006) The puzzle of falling enrolments in physics and chemistry courses: putting some pieces together in Research in Science Education, pp285-311

An analysis of recent Higher School Certificate data in New South Wales found that “... *the largest enrolments growth has occurred in subjects such as community and family studies, PDHPE [personal development, health and physical education], dance and legal studies... some of the trends can be explained by students’ perceptions of how subjects relate to potential careers.*”¹⁵⁴

This supports the anecdotal evidence given to the committee by submitters and witnesses, who indicate that career preferences and related university course entrance requirements, as well as individual interest, are the main drivers of those decisions.

5.1.5 How to address the decline in participation

Different ways to address declining participation in mathematics, chemistry and physics were suggested by inquiry participants and have also been identified in research and reports. These include introducing different assessment methods, new syllabi, providing students with sufficient reward for their effort in ‘more difficult’ subjects, providing a more practical focus in the teaching of these subjects, improving the relevance of the subjects, increasing engagement and fun in teaching, introducing a more innovative pedagogy and bringing science teaching back into alignment with the needs and interests of contemporary society and contemporary youth.

A teacher, who is also a former panellist and panel chair, believes that “... we would get greater participation for students who have facility in mathematics and science to study and then display their knowledge if we changed the assessment style.”¹⁵⁵ Another inquiry participant considers that “[s]yllabuses should be re-written to place emphasis on repetition and rote learning of times tables and other basic processes from Prep-Year 10. This would increase student confidence, ability and participation in these subjects in Years 11 and 12.”¹⁵⁶

Research conducted by ACER identified that “... the dominant mode of school and tertiary science has somehow got out of kilter with the needs and interests of contemporary society and contemporary youth.”¹⁵⁷ There appears to be strong convergence of views in the many published government and government funded reports that the way to address declining participation in the study of science subjects is to ensure those subjects are true to the very nature of science – inquiry-focused – and relevant to understanding the world the students live in.¹⁵⁸

A report from the Australian Office of the Chief Scientist to a former Prime Minister on ways to increase participation in mathematics, statistics and science courses at university advised:

*Physics and chemistry (and some mathematics) are seen as difficult subjects. Students will be more inclined to choose them if there is sufficient reward for effort ... The perceived relative difficulty of these subjects needs to be matched by appropriate rewards.*¹⁵⁹

¹⁵⁴ Sydney Morning Herald, *Geography loses as HSC students map their futures*, 5 October 2013

¹⁵⁵ Mr Jeff Close, Submission 154, p1

¹⁵⁶ Mr Andrew Jackson, Submission 78, p2

¹⁵⁷ Tytler, Russell (2007) *Re-imagining science education – engaging students in science for Australia’s future*, Australian Council for Educational Research, p67

¹⁵⁸ For example AIG, 2013, p4; Tytler, 2007 (ACER); Office of the Chief Scientist. Also Canada, UK, USA reports on the ‘crisis’

¹⁵⁹ Office of the Chief Scientist (2012) *Mathematics, engineering and science in the national interest*, p9

The Commonwealth Office of the Chief Scientist has also called for semester-long work related projects or placements to be part of the course for first year university students, suggesting a practical focus as means of sparking interest. Improving the relevance of STEM subjects was also suggested as a way to encourage participation in these subjects at undergraduate level.¹⁶⁰ While that recommendation relates to university education programs, it is interesting to note that according to the AIG, its 2012 Survey of Workforce Development Needs shows there is an even greater need for workers with STEM skills in a range of occupations which do not require a university degree, including technicians and trade workers, than for professionals.¹⁶¹

It could be concluded that the Chief Scientist's rationale applies equally to senior school STEM education – mathematics, physics and chemistry (along with other sciences). Some schools have taken this to a very new level, replacing formal maths classes with a flexible student-led study program which integrates online learning with specially created work spaces. This initiative has, apparently, “...increased student engagement and introduced fun into maths”.¹⁶²

The AIG has called for the adoption in schools of a more innovative pedagogy which teaches STEM skills in an engaging and integrated way; the development of measures to encourage girls to remain engaged in STEM skills, and the need to commence an expanded engagement with STEM skills at primary schools where students first encounter these areas.¹⁶³

5.1.6 Conclusions

Despite the data showing there has been a decline in the overall participation in most of the subjects that are within the scope of this inquiry, a decreasing completion rate for these subjects and an increasing drop-out rate, no evidence has been identified that links these patterns to senior assessment methods. In fact, if senior assessment methods were a reason for the decreasing participation, the increasing participation and completion rate in mathematics C would be an anomaly. It is essential to look beyond senior assessment methods to account for the patterns of participation in senior mathematics, chemistry and physics.

While actual enrolment numbers and the weighted population has increased for all subjects, the participation rate has increased in some subjects (mathematics A and C), and decreased in others (mathematics B, chemistry and physics). The completion rate has decreased for all subjects except mathematics C. With regard to the percentage of students that drop out of subjects, mathematics A has the highest drop-out rate, followed by mathematics B, chemistry, physics then mathematics C. Data shows that mathematics C is unique, being the only subject to have a relatively consistent participation rate over the decade, the only subject to experience an increase in its completion rate when all others decreased, and the only subject that does not have an increasing drop-out rate, even though that rate has varied over the decade.

The number of male enrolments in physics increased slightly over the decade and female enrolments decreased. As a proportion of the weighted population, both decreased slightly.

¹⁶⁰ Office of the Chief Scientist, December 2012, *Top Breakthrough Actions for Innovation*, p9

¹⁶¹ AIG, 2013, p4

¹⁶² Sydney Morning Herald, *School subtracts maths classes*, 13 March 2013

¹⁶³ Australian Industry Group, 2013, p12

As a proportion of the weighted population, chemistry enrolments decreased by 1% for males and females. Enrolments in mathematics A increased for both males and females over the decade, with female students accounting for 55% of enrolments in 2012. Enrolments in mathematics A as a proportion of the weighted population remained fairly steady. Enrolments in mathematics B increased by 4% for males and females. More males (53%) studied mathematics B than females. Enrolments as a proportion of the weighted population decreased for both males and females over the decade. Mathematics C enrolments for males and females increased over the decade, and there was a larger increase in female enrolments. Approximately double the number of males studied mathematics C than females.

The decrease in participation of mathematics A, B, chemistry and physics is in line with that observed Australia-wide and internationally, in that participation rates in mathematics and science have decreased for more than two decades. It was recently reported that in New South Wales, the *“... physics cohort is the same size as it was in 2003 and the number of students studying advanced mathematics has dropped 17 per cent.”*¹⁶⁴

Research shows that many factors affect subject participation, including achievement and experiences in early years, the increasing number of subjects available to students, socioeconomic background and university prerequisites and perceptions. No evidence has been received to indicate that Queensland's senior assessment methods influence participation.

Of all the views expressed by inquiry participants, it seems that ‘participation levels have decreased, but not because of assessment methods’ has been demonstrated to be the most accurate observation. Given that the concerns about declining mathematics and scientific skills is a universal issue in Australia and other OECD countries, it seems unlikely that Queensland's assessment system is a cause of the ‘big picture’ problems.

Committee comment:

The committee notes the diverse views presented by inquiry participants about student participation rates in senior mathematics, chemistry and physics, and the perceived effect of senior school assessment on participation. Given the diversity of views it was prudent to turn to objective, state wide data on student participation over the decade. In line with many of the views we received, this data confirmed that participation levels in these subjects have decreased over the decade. A similar decrease has been observed at a national and international level.

The committee notes there has been a decline in the number of students electing to study ‘traditional’ subjects, due to the increased choice now available to students. For example, in Victoria, the number of students studying Australian History has halved since 1995.¹⁶⁵ In New South Wales since 2003, the participation rate for HSC geography has decreased by 41%, mathematics by 32% and physics by 15%. Given this, it could be seen as something of an achievement that the participation rate has not decreased further in Queensland for mathematics, chemistry and physics. However, whether the decline has been slowed by Queensland assessment methods is not something we can answer, however.

¹⁶⁴ Sydney Morning Herald, *Geography loses as HSC students map their futures*, 5 October 2013

¹⁶⁵ The Age, *Passion for Australia's past becomes history*, 5 October 2013

There appears to be no evidence to support an argument that lower participation rates are due to the assessment methods or processes used to assess these subjects at a senior level in Queensland. The committee also considers it unlikely that any decreasing participation in these subjects is a result of assessment methods, given the similar national and international patterns of participation.

The committee notes that universities have lowered the general entrance requirements for some courses, and the possible impact this is likely to have on participation levels in these subjects at the senior school level. The committee also notes with interest, that student can obtain higher OP scores through studying subjects that may be unrelated to the degree they seek entry to.

It is interesting to note the many factors that affect student participation rates, including students' experience of learning in early years, the increasing choice of subjects available to students, socioeconomic background, whether the subject is a prerequisite for university and student perceptions of what post-school options these subjects may lead to. The committee considers there to be many more factors that affect participation rates and inform a student's choice of subject than those we have identified.

6 Student performance

A number of inquiry participants expressed concern about the performance of Queensland students in senior mathematics, chemistry and physics, and suggest that this may be related to the assessment methods used. Queensland, national and international data has been analysed to determine the performance of Queensland students and whether this can be linked to senior assessment.

6.1 Views of inquiry participants

With regard to the effect of senior assessment methods on student performance, the committee heard views ranging from the performance level of students is unknown, students perform poorly because of assessment methods and is it meaningless to compare performance between schools and between students due to the current senior assessment methods.

A teacher, who is also a Learning Area Coordinator for senior mathematics and was a member of a district review panel highlighted a number of issues regarding student performance:

*Not only is it difficult to decide on a result for an individual student, but equating the various possible combinations of student performance to compare students is an absolute minefield... it is little doubt that teachers often struggle with decisions about assessment, and one wonders if the decision is sometimes little more than an educated guess.*¹⁶⁶

The principal of Hubbard's School expressed a similar view, noting that "Queensland students live with getting 'A or B or C. It's never a percentage. Hence, never specific and always difficult to gauge progress or decline."¹⁶⁷

Dr Arnison, considers the current assessment process to be imprecise:

*The Queensland experiment to restrict judgements about student performance to the use of criteria and standards descriptors alone in the empirical sciences (physics, chemistry) and mathematics has failed because this approach is too imprecise to produce valid and reliable decisions on student performance in these subjects.*¹⁶⁸

Dr Norton, a senior university lecturer in mathematics education, former secondary mathematics teacher, author of books on specific pedagogies for teaching primary and middle school mathematics considers that Queensland students perform poorly in mathematics and science, which "... may stem from low academic expectations in these subjects arising from current invalidities in senior school assessment."¹⁶⁹

¹⁶⁶ Mr Trevor Barrett, Submission 207, p4

¹⁶⁷ Hubbard's School, Submission 252, pp4-5

¹⁶⁸ Dr B. J. Arnison OAM, Submission 228, p19

¹⁶⁹ Dr Stephen Norton, Submission 30, p1

A teacher of senior physics, who is also a panellist, told the committee that performance comparison between schools and students is meaningless:

*No two schools follow the same work program, or teach the same topics, or set and mark the same assignments and exams. This makes performance comparison between schools, and between students from different schools, meaningless.*¹⁷⁰

6.2 Student performance in Queensland

6.2.1 Performance of Year 11 and 12

Analysis of Queensland student performance in senior mathematics, chemistry and physics in comparison with students in other states is not currently possible.

Different curriculums, assessment methods and reporting language and formats are used in each jurisdiction across Australia, so it is not possible to use state-based results to compare student performance. The limited data about student performance at the senior level makes comparability of outcomes difficult, and thus, makes it difficult to see whether different assessment systems are related to any differences in performance.

The Queensland Core Skills (QCS) test is sat by OP eligible Year 12 students each year. The test examines a set of generic skills identified in the Queensland senior curriculum, rather than particular knowledge of subjects. The QSA website advises that “[t]he test assumes that candidates have basic levels of general knowledge and vocabulary and Year 10 knowledge of mathematical operations.”¹⁷¹ Students receive a grade from A – E and the group results contribute to the scaling of OP scores. Therefore, as well as not being an indicator of subject achievements, the results of this test do not provide an indication over time of the overall achievement of students. In addition, as the percentage of OP eligible students decreased from approximately 53% of the weighted population in 2002 to 41% in 2012, any analysis of OP results would not reflect the total senior student population.

6.2.2 Performance of other year groups

While there is no statewide, national or internationally consistent test for students in Years 11 and 12, there is extensive performance data available for the junior years. TIMSS, PISA and NAPLAN collect data at regular intervals about the performance of students, which can be compared between Australian jurisdictions, and for TIMSS and PISA, internationally.

Trends in International Mathematics and Science Study (TIMSS)

TIMSS assesses the mathematics, science and reading achievement of a sample of students in Year 4 and 8, every four years. Over 50 countries participated in 2011. Data collection commenced in 1995 and the most recent assessment was in 2011; the next data collection will take place in 2015. TIMSS results show comparative international achievement and report the number of students that reach internationally benchmarked standards. In Australia, ACER implements TIMSS data collection.

¹⁷⁰ Name suppressed, Submission 51, p2

¹⁷¹ Queensland Studies Authority, www.qsa.qld.edu.au/2318.html <site accessed 10 September 2013>

Data from the 2011 TIMSS showed that Queensland students performed significantly worse in Year 4 maths and science than they did in Year 8. In Year 4 in 2011, Queensland performed better than only the Northern Territory in both science and maths, whereas by Year 8, Queensland performed third and fourth best out of the other states and territories in science and maths respectively.¹⁷² Even though Queensland ranked third and fourth, the scores were not statistically significantly different from those of comparable states (NSW, Vic, WA and SA), and were only significantly less than the ACT.¹⁷³

With regard to benchmarks, 36% of Year 4 students in Queensland achieved the low or below low benchmark in mathematics. This is more than the Australian rate of 30%. The average Australian benchmark for high and advanced achievement is 35%. Queensland had 26% of Year 4 students achieve this benchmark. This rate was higher than only the Northern Territory (25%). Queensland had the largest percentage of students at the intermediate level (39%), compared with an Australian average of 35%.¹⁷⁴ A similar pattern was observed for Year 8 students in mathematics, although the percentage of Queensland students achieving a high and advanced benchmark (26%) was closer to the Australian average of 29%.

Similar to Year 4 mathematics, Queensland had more students (34%) than the Australian average (29%) performing at a low or below low benchmark in science in Year 4. Only the Northern Territory had a larger proportion of students performing at the low and below low benchmarks. Queensland and the Northern Territory both had the lowest percentage of students achieve the high and advanced benchmarks, at 27% each. Again, Queensland had the largest percentage of students at the intermediate level (39%).¹⁷⁵

In line with the patterns described above, there were more Queensland Year 8 science students (31%) than the Australian average (30%) performing at the low or below low benchmark, however, in comparison to other states and territories Queensland achieved the same percentage as Victoria and had a smaller percentage of students at this level than South Australia, Tasmania and the Northern Territory. Although the percentage of students achieving the high and advanced benchmarks did not reach the Australian average (36%), Queensland had a larger percentage achieve this level than the same three states that had a higher percentage of students underperforming.¹⁷⁶

Since 1995, there has been a significant gender difference in the results obtained in Year 8 science in TIMSS, in favour of males.¹⁷⁷

Program for International Student Assessment (PISA)

The OECD PISA tests a random sample of students from approximately 30 countries. It aims to “... evaluate education systems worldwide by testing the skills and knowledge of 15-year-old students.”¹⁷⁸ Mathematics, science and reading have been assessed every three years since 2000. PISA assesses students’ ability to “... apply their knowledge and skills to real-life

¹⁷² Thomson et al (2011) Highlights from TIMSS and PIRLS 2011 from Australia’s perspective, ACER, p16

¹⁷³ Ibid, p14

¹⁷⁴ Ibid, p24

¹⁷⁵ Ibid, p30

¹⁷⁶ Ibid, pp31-32

¹⁷⁷ Ibid, p8

¹⁷⁸ OECD Programme for International Student Assessment www.oecd.org/pisa/aboutpisa/ <site accessed 10 September 2013>

*problems and situations rather than how well they have learned a specific curriculum.*¹⁷⁹
The Australian Council for Research Education (ACER) advises that:

*In Australia, PISA is included in the National Assessment Program. Together with the IEA's Trends in International Mathematics and Science Study (TIMSS), PISA provides data from internationally standardised tests that enables Australia to compare and monitor its performance with that of other countries.*¹⁸⁰

In 2009, Queensland ranked fourth in mathematical and scientific literacy and above the OECD average. In addition, its performance in mathematical literacy was not considered to be statistically significantly different to most of the states that achieved a higher average score:

*There was not a lot of variation seen between Western Australia, the Australian Capital Territory, Queensland, New South Wales and Victoria, with scores not significantly different to each other and all within the range of 512–529 score points.*¹⁸¹

Similar to the results of TIMSS, statistically significant gender differences were observed in Queensland with males scoring higher in mathematical literacy than females.¹⁸²

With regard to scientific literacy, Queensland again performed higher than the OECD average and similarly to states that achieved a higher average score:

*The Australian Capital Territory, Western Australia, New South Wales and Queensland performed similarly statistically to each other, with the Australian Capital Territory and Western Australia performing significantly higher than four states (Victoria, South Australia, Tasmania and the Northern Territory).*¹⁸³

High performing Asian countries satisfaction with TIMSS and PISA

It is worth noting that the 'high performing' Asian countries are not necessarily satisfied that the TIMSS and PISA scores are measuring what is important.

While Western countries show great admiration of the outstanding scores of East Asia and lament on their own abysmal performance, the East Asian education systems, while celebrating their achievement, are worried about something that the media in Western countries rarely mentions. Here are some examples:

Japan:

But enthusiasm for studying science was below the global average among Japanese second-year junior high students. The fourth-graders interest in arithmetic was also below the world average. –[Japan Times](#)

¹⁷⁹ Programme for International Student Assessment (2009) *Highlights from the full Australian Report- Challenges for Australian Education: Results from PISA 2009*, ACER, p1

¹⁸⁰ Australian Council for Educational Research, PISA Australia www.acer.edu.au/ozpisa/pisa-australia/ <site accessed 10 September 2013>

¹⁸¹ Programme for International Student Assessment, *Challenges for Australian Education: Results from PISA 2009*, p183

¹⁸² Ibid, p185

¹⁸³ Ibid, p228

Singapore:

Nevertheless, the study showed that the Republic still has to work on students' confidence in approaching the subjects of math and science. TIMMS, which measured this component for the first time, saw Singaporean students exhibiting positive learning attitudes.

However, their confidence levels were found to be lower compared to students in other education systems. –[Today Online](#)

Hong Kong:

Hong Kong students reading scores topped the world but their motivation to read ranked bottom, with only 54% of students reported that they were motivated to reading, far below the international average of 74%. They also ranked low in reading interest and confidence.

Professor Xie of Hong Kong Institute of Education, who is in charge of the study, found similar situations in Taiwan, Korea, and other test-oriented countries and regions. Using Hong Kong as an example, there is a tradition that both parents and teachers value tests and demand students to study hard, even when they have no interest. –Translated from [Mingpao](#)

Chinese Taipei (Taiwan):

Despite the outstanding achievement in TIMSS and PIRLS, the studies show that students have less positive attitude to and low confidence in math, science, and reading. There is also a gap between rural and urban students. The Ministry of Education proposed the following strategies: 1. Reform the entire education system, lower academic pressure, break the shackles of testing, and give back students the joy of learning... –Translated from [World People News](#).¹⁸⁴

It has also been pointed out that measures of entrepreneurship indicate much lower levels in Asian countries than in Western countries, and entrepreneurship is considered a key contributor to economic success.

NAPLAN

Since 2008, NAPLAN has annually assessed how students in Australia perform in Years 3, 5, 7 and 9 in the areas of reading, persuasive writing, spelling, grammar and punctuation and numeracy.¹⁸⁵ In addition, sample assessments have tested students' skills and understanding in science literacy, amongst other areas. This occurred in 2003, and was repeated in 2006, 2009 and 2012.¹⁸⁶

Similar to Queensland's NAPLAN results of 2008 and 2011, students performed below average in all year groups and assessment areas in 2012. However, when 2011 results are compared to 2012, Queensland showed a greater improvement than any other state or

¹⁸⁴ Yong Zhao, University of Oregon

¹⁸⁵ National Assessment Program www.nap.edu.au/naplan/naplan.html <site accessed 10 September 2013>

¹⁸⁶ National Assessment Program www.nap.edu.au/nap-sample-assessments/nap-sample-assessments.html <site accessed 10 September 2013>

territory.¹⁸⁷ This likely reflects the impact of Queensland students having had an additional year of schooling since 2007, when Prep was introduced. Further improvements are likely following the move of Year 7 into secondary school, with specialist resources from 2015.

In 2012, Year 3 numeracy results were not significantly different to those of Western Australia and South Australia, and were better than only the Northern Territory and significantly worse than the remaining states and territories. Average achievement was below the Australian mean (380.9 v 395.5), and the proportion of students performing at or above the national minimum standard (92.7%) was less than the Australian average (93.9%).¹⁸⁸ No statistically significant change in results from 2011 were observed, but 2012 results were significantly better than those of 2008.¹⁸⁹

The Year 5 numeracy results were not statistically significantly different to those of Western Australia and Tasmania. However, they were significantly better than those of South Australia and the Northern Territory and significantly worse than the remaining states and territories. Average achievement was below the Australian mean (476.1 v 488.7) and the proportion of students performing at or above the national minimum standard (91.7%) was less than the Australian average (93.3%).¹⁹⁰ Similar to Year 3 results, there was no statistically significant change in Year 5 numeracy results from 2011, but 2012 results were significantly better than those of 2008.¹⁹¹ From Year 3 to Year 5, Queensland students made greater gains in numeracy achievement than almost all other states and territories from 2008-2010, 2009-2011 (a slightly better improvement was seen for Western Australia) and 2010-2012.¹⁹²

The Year 7 numeracy results were not statistically significantly different from those of Western Australia, South Australia and Tasmania, and were better than only the Northern Territory. Average achievement was below the Australian mean (532 v 538.1), and the proportion of students scoring at or above the national minimum standard was the same as Australian average (93.8%).¹⁹³ The numeracy results for Year 7 students in 2012 were significantly worse than in 2011 and 2008.¹⁹⁴ From Year 5 to Year 7, Queensland made the greatest or second greatest gains in numeracy achievement of all states and territories from 2008-2010, 2009-2011 (a slightly better improvement was seen for Western Australia) and 2010-2012 (a slightly better improvement was seen for Western Australia).¹⁹⁵

The Year 9 numeracy results were not statistically significantly different from those of South Australia and Tasmania. Results were better than only the Northern Territory, and were worse than the remaining states and territories. Average achievement was below the Australian mean (574.6 v 584.2), and the proportion of students scoring at or above the national minimum standard was the same as Australian average (93.7%).¹⁹⁶ There was no significant difference in Year 9 numeracy results from 2008 and 2011. Poor improvement in

¹⁸⁷ NAPLAN and ACARA (2012) *National Assessment Program Literacy and Numeracy – Achievement in Reading, Persuasive Writing, Language Conventions and Numeracy*

¹⁸⁸ Ibid, p62

¹⁸⁹ Ibid, p294

¹⁹⁰ Ibid, p110

¹⁹¹ Ibid, p294

¹⁹² Ibid, p330

¹⁹³ Ibid, p174

¹⁹⁴ Ibid, p279

¹⁹⁵ Ibid, p334

¹⁹⁶ Ibid, p254

numeracy results was observed Year 7 to 9 in 2008-2010, 2009-2011 and 2010-2012, and Queensland students achieved below the Australian improvement average for all time periods.¹⁹⁷

With regard to the 2009 National Assessment Program – Science Literacy, Queensland students performed better than only SA and the NT, however, results were not statistically significantly different from NSW, WA, Tasmania and SA. However, when the strictness for establishing statistical significance was increased, Victoria was added to this list. Queensland performed significantly better than only the NT.¹⁹⁸ The report noted that “[i]t can be seen that the average age of students varies considerably between states and territories with Queensland having the youngest students on average.”¹⁹⁹

Reviews of student performance

An independent review of literacy, numeracy and science standards in Queensland primary schools was conducted in 2009. Amongst other things, the review analysed “... the performances of Queensland students in national and international achievement surveys.”²⁰⁰

The review found that “[s]tudents in the middle primary years (Years 3, 4 and 5) in Queensland tend to have literacy, numeracy and science achievement levels below those of students in all other states and territories with the exception of the Northern Territory.”²⁰¹ This may partly be explained by the fact that the Queensland students had one less year of schooling than their counterparts interstate. As students progress towards Year 10, they:

*... appear to make more rapid progress than students in these three states [Tasmania, Western Australia and South Australia] in the intervening years. Nevertheless, the performances of Queensland students in Years 7 to 10 are, on average, significantly below those of students in New South Wales, Victoria and the Australian Capital Territory.*²⁰²

Following the 2009 review, the then Government committed the QSA to analyse Queensland students’ performance in national and international tests to identify priority areas for professional development programs.²⁰³ This analysis was completed in 2011 and considered students’ performance in TIMSS 2007, PIRLS 2006 and NAP-Science Literacy 2006. Similar to the 2009 review, results showed that Queensland students’ results and rank in comparison to other Australian jurisdictions generally improved as students got older:

Queensland students’ results are clearly behind those of other jurisdictions except for the Northern Territory in Year 3, but by Year 9 they are roughly the

¹⁹⁷ Ibid, p338

¹⁹⁸ ACARA (2009) *National Assessment Program- Science Literacy Year 6 Report*, p26

¹⁹⁹ ACARA (2009) *National Assessment Program- Science Literacy Year 6 Report*, p22

²⁰⁰ Masters, Geoff (2009) *A shared challenge – Improving literacy, numeracy and science learning in Queensland primary schools*, Australian Council for Educational Research, pv

²⁰¹ Masters, Geoff (2009) *A shared challenge – Improving literacy, numeracy and science learning in Queensland primary schools*, Australian Council for Educational Research, pv

²⁰² Masters, Geoff (2009) *A shared challenge – Improving literacy, numeracy and science learning in Queensland primary schools*, Australian Council for Educational Research, pv

²⁰³ Government response, *A shared challenge – Improving literacy, numeracy and science learning in Queensland primary schools* <http://education.qld.gov.au/mastersreview/pdfs/gov-response-masters-review.pdf> <site accessed 10 September 2013>

same as or ahead of other jurisdictions except for New South Wales, Victoria and the ACT.

*In terms of informing professional development, this suggests that science teaching in Prep – Year 6 should be particularly targeted.*²⁰⁴

The analysis also concluded that:

*... the area of greatest weakness is in the lower to mid primary years (up to Year 6). This would come as no surprise to researchers in the field of science education, since this period of schooling is most frequently identified as the time when negative attitudes to science teaching and learning can be established.*²⁰⁵

Summary of student performance in junior years

Dr Norton, a senior university lecturer in mathematics education, analysed TIMSS and NAPLAN data and concluded that “... international tests illustrate that as a nation Australia is underperforming in key disciplines and national testing shows that Queensland is one of the lower performing States.”²⁰⁶

In 2011, the mathematics and science achievement results in TIMSS showed that Queensland students in Year 4 performed poorly in achievement and benchmarking in maths and science, and achieved better than only the Northern Territory. Results showed that too many Queensland students achieved low average scores and too few reached high or advanced levels. A stronger performance was achieved by Year 8 students in 2011, performing third and fourth in science and maths out of 8 states and territories. Although a higher than average proportion of students achieved low achievement levels, this was equal to Victoria and better than South Australia, Tasmania and the Northern Territory. PISA demonstrates that 15 year old students’ application of mathematics and science was comparable to other higher performing states (Australian Capital Territory, Victoria, New South Wales and Western Australia).

In 2012, NAPLAN results showed that Queensland student achievement in numeracy was below the Australian mean in all year groups tested (Year 3, 5, 7, and 9). In addition, Years 3 and 5 performed below the national minimum standard, whereas Year 7 and 9 equalled the minimum standard. A significant improvement in results was observed when Year 3 and 5 results were compared to those of 2008. No significant difference was observed in the results of Year 9 students, and the results of Year 7 students were significantly worse than those of 2008. A high level of improvement was achieved from Year 3 to 5 and Year 5 to 7, when the rates of improvement were compared to most other states and territories from 2008-2010, 2009-2011 and 2010-2012. Results from Year 7 to 9 showed poor improvement, at a level below the Australian average.

In terms of what students know (NAPLAN and TIMSS), Queensland students perform poorly when compared to other states and territories, and generally below the Australian average. Application of knowledge (PISA) is comparable to four other higher performing states.

²⁰⁴ Queensland Studies Authority, *Science test analysis – Report to the Queensland Education Performance Review Implementation Steering Committee*, May 2011, p31

²⁰⁵ Queensland Studies Authority, *Science test analysis – Report to the Queensland Education Performance Review Implementation Steering Committee*, May 2011, p3

²⁰⁶ Dr Stephen Norton, Submission 30, p8

TIMSS data (2011) showed poorer performance in Year 4. NAPLAN data shows a similar pattern, that is, lower performance in the junior years (Year 3 and 5) and better performance (although still lower than others) in Years 7 and 9, where the national minimum standard is met. Greater improvement is apparent in the junior years (Year 3 to 5 and Year 5 to 7) than in Year 7 to 9, where performance is below the Australian average. NAPLAN shows Queensland is the most improving state in numeracy overall. With regard to science literacy, although Queensland ranked poorly, its results were not statistically different to most other states.

6.3 Is performance linked to senior assessment methods?

No evidence has been received by the committee to indicate that the performance of Queensland students is linked to the assessment methods used in senior mathematics, science and chemistry. Without data on the performance of Year 11 and 12 students, perhaps through the introduction of a common assessment task, the effect of assessment methods on senior performance cannot be established. In addition, research indicates that relatively poorer performance in Queensland starts as early as Year 3. It stands to reason that the performance of students at senior level is affected by a number of factors, possibly including performance in the junior years.

This could include, for example, participation in early childhood education. The majority of Queensland children do not attend kindergarten, and in 2008 Queensland had the lowest rate of children attending kindergarten (28%). This increased to 32% in 2009²⁰⁷ and has been increasing since then to 77% in 2007. There is a current target to achieve universal access by 2014.²⁰⁸ The importance of early childhood education has been well established. In a report commissioned by the Queensland Office for Early Childhood Education and Care, Department of Education and Training, the value of early childhood education was noted, “... not only in supporting development of early literacy and numeracy but also in facilitating the learning of institutional routines that are prerequisite for successful school participation and attainment.”²⁰⁹ Therefore, it is possible that a history of poor kindergarten participation rates could be one factor that affects the performance of Queensland students. This can be expected to improve.

Another factor that has been linked to student achievement by a number of research programs is teacher quality.

*First, while student demographic characteristics are strongly related to student outcomes at the state level, they are less influential in predicting achievement levels than variables assessing the quality of the teaching force. Second, when aggregated at the state level, teacher quality variables appear to be more strongly related to student achievement than class sizes, overall spending levels, teacher salaries (at least when unadjusted for cost of living differentials), or such factors as the statewide proportion of staff who are teachers.*²¹⁰

²⁰⁷ Queensland Department of Education and Training (2010) *Annual Report 2009-10*, p44

²⁰⁸ Hansard (Queensland), 23 July 2013, Hon JP Langbroek, p27

²⁰⁹ Thorpe, Karen; Vromans, Lyn and Bell-Booth, Rachel (year) *Accessing Kindergarten in Queensland- A report to the Queensland Office for Early Childhood Education and Care*, Queensland University of Technology, p13

²¹⁰ Darling-Hammond, Linda (1999) *Teacher quality and student achievement: A review of state policy evidence*, Center for the Study of Teaching and Policy, University of Washington, p38

The importance of teacher quality has been recognised by the Queensland Government, through the Improving Teacher Quality National Partnership. This is “... a joint initiative between the Australian Government, Education Queensland and the Catholic and Independent schooling sectors. The agreement acknowledges that teacher quality is the single greatest influence on student engagement and achievement. It aims to support all teachers and school leaders to strengthen the quality of teaching in every classroom, every day.”²¹¹

With regard to lower performance in the junior years, Professor Masters recommended that the professional development of teachers be targeted to specific year levels, to increase their confidence in teaching science:

*... professional development is best targeted, not in certain domains, but rather at particular year levels. International research suggests that the weaknesses of teaching science at the lower primary year levels can be attributed to weaker content knowledge of teachers at these year levels. This leads to less confidence in teaching the subject effectively in interesting and engaging ways, and it is in the areas of Applying and Reasoning (as opposed to Knowing) that Queensland students show relative weakness in the lower primary school. Aligning professional development in these areas with the implementation of the Australian Curriculum will provide a meaningful context in which teachers could re-examine their content knowledge and build their pedagogical content knowledge.*²¹²

It also seems unlikely the curriculum is contributing to any poorer outcomes for Queensland compared with other Australian jurisdictions. A 2007 ACER study found that:

*Physics and Chemistry are subjects with a very high degree of national curriculum consistency. Each state and territory offers subjects called Physics and Chemistry, and an analysis of the curriculum in these subjects shows that 85 to 95 per cent of curriculum content—both subject matter and intended skills/understandings—is common to all eight jurisdictions.*²¹³

In addition, although differences in performance on tests such as NAPLAN, TIMSS and PISA cannot readily be linked to assessment systems, they could well be linked to having different syllabuses. However, more evidence would be required to make that firm connection.

Dr Norton, a senior university lecturer in mathematics education, former secondary mathematics teacher, author of books on specific pedagogies for teaching primary and middle school mathematics, considers it will take more than changing assessment to improve performance:

We can tinker with assessment in senior maths, physics and chemistry, and we should, because changes have the potential to drive reform, but this will achieve

²¹¹ Queensland department of Education and Training, *Improving teacher quality national partnership*, <http://education.qld.gov.au/nationalpartnerships/imp-teach-quality.html> <site accessed 12 September 2013>

²¹² Queensland Studies Authority, *Science test analysis – Report to the Queensland Education Performance Review Implementation Steering Committee*, May 2011, p3

²¹³ Masters and Matters, 2007

*little without urgent reform of teaching, teacher training and related syllabus reform in Queensland.*²¹⁴

Committee comment

Although the committee was tasked to consider the senior assessment of students, we were surprised to learn there is limited performance data to indicate how senior students actually perform, both yearly and over time. This limited the committee's analysis of any correlation between senior assessment and student performance. The committee considered comparing the OP score, however, this represents a declining proportion of students - approximately 41% in 2012 - and would not have been a valid indicator to use.

Given this situation, the committee turned to national and international tests completed by Queensland students in the junior years. Interestingly, these tests show that overall, Queensland students generally perform worse than most other Australian jurisdictions. However, they have recently shown signs of improvement. For example, in 2008, 2011 and 2012 NAPLAN students performed below average in all year groups and assessment areas. However, students showed greater improvement in 2012 than any other jurisdiction. Similar results were observed in Year 4 mathematics and science in the TIMSS assessment - which assesses achievement of international benchmarks. By Year 8, the committee notes, student results were comparable to high performing states.

In PISA - which tests the ability of 15 year old students to apply their skills and knowledge - Queensland students ranked above the OECD average and differences from high performing states were not statistically significant. The committee notes with concern the significant gender differences observed in favour of males, in both TIMSS and PISA results.

As problems in student performance can be identified as early as Year 3, and given the lack of data about the performance of students in senior maths, chemistry and physics, the committee cannot make any correlation of senior assessment methods and comparatively poor performance by Queensland students. The committee acknowledges that until recently, Queensland students had a year less schooling and were younger than their counterparts in other jurisdictions. The impact of this on NAPLAN results are noted. The committee is pleased to observe the improvement in NAPLAN results in 2012, and hopes this is a pattern that continues in 2013. The committee considers the introduction of Prep as the first year of schooling and the transition of Year 7 to secondary school will assist the continued improvement in these results.

Much has been made of Australian students' performance on the international PISA and TIMSS tests by politicians arguing for a particular policy position, and by those seeking to demonstrate that Australia's current approaches to education will lead to Australia not being globally competitive in terms of economic development. Australia is not alone here: the United States and United Kingdom, for example, are all ranked comparatively poorly compared with Asian countries. The committee considers that to draw inferences about a country's education system - let alone Queensland's approach to senior assessment in maths, chemistry and physics - and its impact on economic development based on this data alone, would be unsound science.

²¹⁴ Dr Stephen Norton, Submission 30, p1

The committee considers that the problems linked to the assessment methods by some submissions are not supported by the data. While ostensibly the range of other likely causal factors, such as tertiary entrance policies, teacher quality and supply, are outside the scope of this inquiry, they need to be identified if only to highlight the complexity of this issue and the folly of attempting to link the assessment system to any perceived problems with the education system as it relates to mathematics, chemistry and physics in Queensland schools.

Factors that the committee considers to be more influential than senior assessment practices in affecting student performance include access to and quality of early childhood education and teacher quality and professional development, as demonstrated in research.

PART TWO

7 Assessment of senior mathematics, chemistry and physics in Queensland schools

This part of the report considers the issues raised during the inquiry, and makes some recommendations for the future.

The methods and processes used to assess student's achievement levels in senior mathematics, chemistry and physics in Queensland are similar to those used for all other senior QSA subjects taught in state schools. These are considered in this report with particular regard to mathematics, chemistry and physics, wherever possible.

To do that, a key question considered by the committee in respect of every issue identified through the inquiry, was: is there anything about assessing achievement in mathematics, chemistry or physics that is intrinsically different from assessing achievement in other subjects?

The foundation content knowledge for mathematics, chemistry and physics - for example multiplication tables or calculations, or chemistry or physics formulae, can be 'right or wrong', but so can the basics of spelling or grammar in English; or of capital cities or rock types in geography. Core content knowledge in most subjects lends itself readily to simple adding up of right and wrong answers to reach a final 'score'.

It is also possible to use numeric marks to standards in assessing the higher order learning areas, as occurs in other Australian jurisdictions, where scores for all tasks are added to achieve a final result that is again linked to explicit standards.²¹⁵

Despite mathematics, chemistry and physics being ostensibly 'objective' subjects, there will always be a level of subjective judgement on the part of a teacher involved in assessing a student's level of achievement – even in assessing core content knowledge – unless an assessment task is externally set. Even then, there is subjectivity in how the test is set: for example, in deciding how many marks a task, or a question within a task is worth, or how well a certain task enables a student to demonstrate the key criteria.

The level of subjectivity will be greater for higher order skills that assess more than 'right' or 'wrong' answers, and where a level of professional judgement comes into play.

Some teachers are clear that the standards-based descriptor approach to assessment supports them to use their professional skills. Others feel that the standards as they are worded now are vague, imprecise and unhelpful, which reduces their ability to support valid assessments by teachers. Some consider that assessment (and therefore, implicitly, teaching) in these subjects at senior level should be focused on the content and procedural knowledge which lends itself readily to right or wrong type answers anyway – and thus is less subjective.

²¹⁵ For example, the Board of Studies New South Wales.

The higher order skills that are required for the 21st century cannot so readily be demonstrated through ‘right’ and ‘wrong’ types of question. Assessment needs to be ‘domain appropriate’²¹⁶, or fit for purpose.

We have also heard that assessment in Queensland is designed to be used as a key element of the learning process. Evidence, including that given by teachers and students during this inquiry, suggests that an element of inquiry based learning does undoubtedly engage many students – particularly in the science subjects which are intrinsically about inquiry, and where relevance is key to engagement.

A UNESCO report tells us that:

...surveys by international groups such as the European Commission (2007) found that schooling in science was often related to learning information rather than to understanding concepts and investigating them. They argue for inquiry-based education, as it has shown to be effective in raising attainment across basic education, contributes to increased student

and teacher motivation for science, and makes a positive contribution to including a wide range of students through their success in science.²¹⁷

Where assessment is part of learning, and learning aims to be relevant and to engage students, it follows that assessment would include methods that are inquiry-based.

This reflects a view that science education should be about more than university entrance. It should aim to increase science literacy for the whole population. As we know, this was a catalyst for the current system in Queensland.²¹⁸

Teaching and learning to meet the requirements of the 21st century may well need to be supported by a more qualitative and possibly complex approach to assessment than would have been the case if content and procedural knowledge were the only focus of the syllabus.

If assessment methods and processes are ‘fit for purpose’, they will not be the same for every subject – or for every task within a subject.

The committee does not want to add to the workload of teachers or students. As Professor Peter Jones pointed out at the committee’s expert advisory forum:

The other issue about assessment is really thinking about what is the operability and feasibility of whatever we decide. Under the current system, there is an enormous amount of work done very well, by and large, by the current assessment system in Queensland, but that is not cheap. There is a large investment that occurs through panels trying to standardise across multiple schools and multiple differences. I have a brother who is a schoolteacher. I think that that consumes a large amount of time of any senior schoolteacher across this state and requires a degree of central coordination.

Whatever move there is to try to improve the quality of assessment, there needs to be an acknowledgement that you do not want to necessarily increase assessment, but if you are having a change in the mix of assessment, that change has to be funded if it is actually going to be achieved and implemented.

²¹⁶ Submission 58, ACER

²¹⁷ UNESCO Education Sector, 2010. *Current challenges in basic science education*, p29

²¹⁸ See part 1 of this report

*To just say, 'Look, we're going to add something in', all of these decisions have a human cost to them. So they really have to be considered like capital investment. If you say that your staff is going to spend so much more time assessing, that means a reduction in time available for teaching. It is just a simple equation and getting that balance correct is very important.*²¹⁹

Some of the suggested reforms to assessment processes and methods that are made in this part of the report would have an impact on the approach to teaching and learning, because as has been identified, assessment, teaching and learning are inextricably linked. However, some concerns were raised that relate to the workload imposed by specific tasks, such as extended investigations, and the validity of those for assessing student achievement. These could be readily addressed even if minimal other changes were made to the current system.

7.1 School-based assessment

Throughout this inquiry, school-based assessment was one of the few areas that did not seem to be entrenched in firmly opposing ideological camps. Although there was some opposition to it expressed, most submitters saw a place for an element of school-based assessment, irrespective of their views about other aspects of senior assessment process and methods in mathematics, chemistry and physics.

The QSA has advised the committee that one goal of school-based assessment is to allow students to demonstrate their achievements in a subject in a range of ways:

*School-based assessment broadens the ways in which students can demonstrate what they have learnt rather than try and predict what examiners might be looking for.*²²⁰

Victoria and New South Wales use school-based assessment in the same way, although the existence of an external exam as well does, according to one NSW teacher, ensure teachers teach the whole syllabus.²²¹

A benefit of providing a range of ways for students to demonstrate their achievements is that it does not discriminate against or advantage any one student over others (for example, those who are less able at written communication can demonstrate their achievements through numeric formulae or practical demonstrations, and vice versa). Providing a range of means for students to demonstrate their achievement and understanding over time should increase the reliability of assessment: two years of work (or longer) does not all come down to one exam, on one day.

The continuous nature of school-based assessment also provides an opportunity for teachers to identify and investigate discrepancies between performances on different tasks, to ensure authenticity of the student's work. It also allows schools to tailor assessment tasks so that they are particularly relevant for students.

The assessment requirements for senior mathematics, chemistry and physics in Queensland do not appear to be more or less onerous for students than in other Australian jurisdictions.

²¹⁹ Hansard, 1 May 2013, Professor Peter Jones, p2

²²⁰ QSA, Submission 129, p4

²²¹ Private conversation, Sydney, 29 August 2013

For example, Victorian students in Year 12 chemistry are required to complete over the year, for assessment purposes:

- one experimental investigation
- two written reports of practical activities (not the same one as the experimental investigation)
- two out of a choice of three other tasks that involve analysis or synthesis and communication of findings and
- one summary report including annotations of at least three practical activities (the subject matters for these must be within fairly specific parameters).²²²

In addition to this, students are preparing for an end of year exam.

In total, the sum of the school based assessment tasks account for 40% of a student's overall assessment, with the external exam accounting for 60%.

While Queensland has 100% school-based assessment, the other extreme of 100% external assessment (usually by exam), with the various coursework tasks not contributing to final assessment, also has issues in terms of workloads and stress. Senior secondary school assessment, as a high stakes assessment, is always stressful.

The views of university academics from the disciplines of mathematics and sciences as expressed to this inquiry were in two broad camps. Some, like Dr Stephen Norton²²³, Professor Jennifer Stow²²⁴ and Dr Tony O'Connor²²⁵, considered that current assessment processes were overly onerous and did not ensure the basic content and procedural knowledge for these subjects was sufficiently taught and learnt. Many teachers who submitted to this inquiry shared that view, arguing that the work involved for both teachers and students in extended investigation tasks in particular meant that there was insufficient time to teach and learn content and procedure. This is discussed further in section 9, assessment tasks.

Professor Stow raised concerns that the repeated, continuous nature of school-based assessment as it currently occurs, was having a negative impact on students' wellbeing. That view was shared by psychologist Anne D'Arcy-Evans, who stated the following:

*It is also clear how assignments and the sense of constant pressure factor in to the low mental health of a sector of our teenagers. Clearly some students respond well to the system of continuous assessment. But for others it causes high levels of distress.*²²⁶

Others, such as Professor Grenfell and Professor Meyers²²⁷, Professor Helen McGillivray²²⁸, Dr Peter Darben²²⁹ and Griffith University Arts, Education and Law Group and Science, Environment, Engineering and Technology Group²³⁰, saw that the current system was

²²² VCE Chemistry Assessment Guide, pp22-27. www.vcaa.vic.edu.au/Documents/vce/chemistry/ChemistrySD-2013.pdf

²²³ Submission 30

²²⁴ Submission 50

²²⁵ Submission 206

²²⁶ Submission 208, Anne D'Arcy-Evans

²²⁷ Submission 122

²²⁸ Submission 92 and see also Hansard, 22 May 2013

²²⁹ Submission 176

²³⁰ Submission 212

preparing students well for their post-school futures. Advice from many of the latter group was that the nature of assessment practices was consistent with the assessment system used at university, and ensured a good grounding for university. Some students agreed with this:

*...now that I am in uni a lot of skills I think I learned while doing those assignments, although at the time they did not seem relevant, they are relevant to me now just in the inquiry based learning, which is a large part of my university degree.*²³¹

And:

*...I know people who do maths research that have to know how to write reports as well, because there is a big push for words in math and not just slabs of numbers on pages. So that does apply to people's degrees.*²³²

While others did not:

*Personally I lack some of the foundational principles of mathematics and as a consequence university maths is proving very difficult at times. Although I must commend the government to some degree as they have changed the curriculum and have increased the difficulty as some of the mathematics I am doing in University, my younger sister is doing in Maths B in grade 10. However she is struggling as well as she has missed the foundational work as I did and has now been hit with incredibly hard content.*²³³

That between academics and between students there was disagreement suggests that there are a number of different systems used at different tertiary institutions, in different disciplines, which may reflect both different philosophies and decisions about 'fitness for purpose'. Incidentally, that university courses are assessed at the individual university level without a common syllabus or assessment methods, means employers and post-graduate schools probably face the same issues in terms of knowing what a student knows and does not know, as some academics now report facing with students exiting senior in Queensland.

School-based assessment allows for more assessment options than a single end of year exam, and the syllabus is broader than can be readily assessed via that method. Teacher Mr Peter Antrobus submitted that:

Assessment needs to reflect the learning experiences that occur in the classroom. If the student is only doing exercises and practicing skills and knowledge, then tests are the best way of doing this. However to provide for the holistic view of the subject and review and check a student's application in using that knowledge, there needs to be a range of assessment pieces that can allow this to occur. Providing students with time to expand on a concept, look at alternatives, assumptions as well as the strengths and limitations of models can only enhance their learning. I believe and have seen this occur time and again in investigations and extended modeling situations. It also allows the lower ability

²³¹ Hansard, 1 October 2013, Ms Emma Nicol, p3

²³² Ibid, Mr Daniel Stoker, p4

²³³ Submission 32, Mr Kyle Hillcoat

*student to achieve some success in the skills that they have learnt because they can be structured to cater for individual ability levels.*²³⁴

Similarly, academic Dr Peter Darben points out:

*The fact that Queensland teachers of senior science subjects must develop, implement and grade assessment items to a high standard which is regularly monitored from experienced teachers outside their school, means that teachers are deeply involved in the entire process of teaching, from instruction right through to assessment. Removal of this through the introduction of external assessment effectively dumbs down the teaching profession.*²³⁵

The QSA advises that:

An external examination ... cannot support teachers to monitor student performance progressively and so inform their teaching and provide students with opportunities to reflect on their own progress.

Research shows that in all education systems, it is assessment that dominates curriculum. If a model of assessment is restrictive, it will narrow the learning experiences of students. Full-cohort tests rarely provide information that teachers can use to improve their teaching and student learning (Pellegrino, Chudowsky & Glaser 2001) especially when the major use of test results is to determine whether students have met a minimal standard or benchmark (Herman, Baker & Linn 2006).

In the Queensland system, assessment is determined within the classroom — not by an external entity at the end of a course of study. It is an integral part of teaching and learning.

School assessment programs include opportunities to determine the nature of students' learning and then provide appropriate feedback or intervention. Because teachers do not teach and then hand over the assessment that counts to external experts to assess what the students have learnt, they are able to practice what is known as authentic pedagogy. This form of pedagogy occurs when the act of teaching involves placing high-stakes judgments in the hands of teachers.

Since the abolition of external exams, Queensland's teachers have been able to broaden the ways in which students can demonstrate what they have learnt rather than try and predict what examiners might be looking for. They have catered to the diverse learning needs of students by offering a variety of assessment experiences. And all of this assessment counts.

*While examinations can be standards-based, it is difficult for them to achieve the broader purposes of assessment. An examination can assess only part of the curriculum and only those skills that are accessible by the written method. They are thus a partial "one shot" method of testing performance.*²³⁶

²³⁴ Submission 57, Mr Peter Antrobus, pp2-3

²³⁵ Submission 176, Dr Peter Darben

²³⁶ QSA, response to supplementary questions of committee, p10

7.1.1 External exams

A submission from Honorary Professor Peter Galbraith brings us back to the fundamental concept of ‘fitness for purpose’ in respect of what the syllabus is aiming to have taught, learned and assessed. Professor Galbraith submits that *“common testing provides an efficient means of assessing certain types of knowledge, but other important forms of knowledge cannot be validly tested this way”*. He noted that test questions can also usefully assess capabilities such as *“resolve conflict; compare / contrast; justify; create; identify and correct error:”*²³⁷

However, if the aim of the syllabus is that students develop the numeracy skills required for participation in personal, work and civic life then ‘testing’ is less valid a means of assessment. Assessing numeracy skills as problem solving, applications and modelling validly and reliably would involve demonstration in context. However, Professor Galbraith points out, this does not have to involve lengthy written assignments.²³⁸

Despite what we understand about the genesis of the current system, the syllabuses for the subjects in question do not explicitly state whether the intent of the course is to prepare students for university study in those disciplines, or for general mathematical and scientific literacy. However the syllabi for mathematics B and C does say that those subjects are useful precursors for tertiary study in those and related disciplines. If this question, which was raised on several occasions during this inquiry and notably at the expert advisory forum, were explicitly addressed in the syllabus it might provide direction on other aspects of the syllabus. In particular, it could determine what the assessment criteria should be, as well as the relative focus on each criteria.²³⁹

Exams, set by individual schools, are the most commonly used assessment task for senior mathematics, chemistry and physics in Queensland. They are in the main used as the supervised assessment tasks that are mandated by the syllabus. The QSA emphasised during this inquiry that:

*I need to clear up a myth that Queensland senior assessment does not include supervised exams. Let me assure you exams are conducted in schools every year along the length and breadth of this state. Just ask any student in years 11 and 12.*²⁴⁰

Many submissions to this inquiry have called for an externally set and marked exam to count for part (or all) of the overall result for maths, chemistry and physics, saying it would promote higher validity and reliability than the current fully school-based assessment model. An external exam could still be standards-based.

In Victoria, the external exam for chemistry (which is worth 60% of a student’s overall assessment) tests *“the key knowledge that underpins the outcomes ... and the set of key skills...”* both of which are specified in the syllabus document, as they are in Queensland.

²³⁷ Submission 69, Honorary Professor Peter Galbraith

²³⁸ Professor Peter Galbraith, submission 69, p2

²³⁹ The Victorian syllabi refer explicitly to employability skills which may be developed through the learning process. See for example VCE Physics study design summary, p5.

²⁴⁰ Hansard, 7 March 2013, Mrs Walton, p3

Some arguments for an external exam to be used to assess senior mathematics, chemistry and physics put forward by the principal of Hubbards School²⁴¹, Ms Helen Stevens, are:

External examinations provide a check on the standards of teaching and learning.

This provides opportunities for students/teachers to check for accurate teaching and marking and also adds to the perception of reliability and trust. Consistency builds trust and hence, reliability.

Standards across jurisdictions and countries can be compared via the presence of some form of external exam. There is no publicly available evidence of the degree of difficulty of knowledge and skills that students are expected to master.

*In Victoria and New South Wales, public examinations are on display. Comparisons can be made and a high level of trust in the standards can be established. The process is perceived to be reliable.*²⁴²

End of course exams can also encourage the retention of knowledge from the entirety of the course. Ms Felicity-Grace Young, who studied the International Baccalaureate program in her senior years of secondary school in Queensland, advised the committee:

*With the IB system.....we had 360 syllabus statements. So over two years we had to learn 360 things and we would get tested on 60 of them. It sounds almost like a waste but I think that I remember so much more from the start of Years 10 and 11 than the majority of my friends remember at the end of their Year 12, because what we learned in grade 10 in term 1 we then had to demonstrate at the end of terms 2, at the end of term 3, 4 and all the way through high school.*²⁴³

Externally set exams mean that all students were tested on a common set of content knowledge. Ms Belinda McEinery, who studied mathematics B and chemistry in her senior course, and who now tutors first year university students in statistics, commented that:

*....there is a great discrepancy in a few student's understanding. So some students will come with more of a theoretical background and not be so good at the calculation side of the material that, even though I do remember studying that in Year 12 mathematics, I suppose there are different ways to go about different unities within the year 12 system. So I think if we had one exam and we knew what was being assessed and which side to approach it, each student would come out with similar competencies.*²⁴⁴

Other recent students Ms Georgie Richards and Mr Jayden Parsons agreed that there was substantial variation in what gets covered at any given school in the fully school-based assessment model. Noting that Mr Parsons had not been taught organic chemistry at all until the 'winding down' phase of Year 12 – and subsequently found it to be an area of emphasis at university – Ms Richards commented:

²⁴¹ Hubbards School uses a one year, Year 12 program with 100% of assessment by QSA-set (external) exam.

²⁴² Submission 252 (Hubbard's School)

²⁴³ Hansard, 1 October 2013, Ms Felicity-Grace Young, p7

²⁴⁴ Ibid, Ms Belinda McEinery, p5

*... we did an entire assignment on organic chemistry. It is a massive variation. That was one of the subject areas that was really concentrated on in our school.*²⁴⁵

And Mr Lynton Hurt, who studied Year 12 HSC in New South Wales, could not see the benefit of individual schools setting their own exams and noted that the final external exam does encourage teaching and learning the whole syllabus.²⁴⁶ Ms Belinda McEinery commented that:

*I suppose if we did have a uniform examination system it would ensure that each student was being instructed in the same material.*²⁴⁷

Another benefit of an external exam for students at smaller regional schools was identified by Ms Georgie Richards, who had completed senior in a smaller regional town in North Queensland:

*... coming from a smaller community, sometimes it was hard to find out [one's ranking] using the OP system. The ranking in the school was not always as correct as what it could be. In the classes that we're studying, the science approach to subjects, they were very small classes and the students in those classes were the cream of the crop as far as the academic side of it at that school because they wanted to go on to university. So to have a state-wide external examination would be good because it would give an idea of where we were sitting in a broader spectrum. That would be very beneficial to the students, particularly when they are coming out of the school into university, to know whether they needed to improve on certain areas or whether or not they were within the average.*²⁴⁸

Although this comment is in the context of the OP ranking system rather than subject-specific assessment, it echoes the concerns raised by some teachers and academics in respect of it being better for a student to find out in Year 12 that they may not be best equipped for a particular career or study decision in that year, rather than later.²⁴⁹

ACER also supports the position that an externally set exam could be 'fit for purpose' – that is, for the purpose of enhancing validity as well as testing aspects of the curriculum.

*In Queensland you see a philosophical preference for particular forms of assessment – for example, teacher devised. The change that is required is from a philosophical commitment to a single way of assessing to a recognition that different methods are appropriate for different kinds of learning even within the same subject. It is our opinion that factual knowledge and conceptual understandings in mathematics, chemistry and physics could be assessed by a common external test while laboratory skills and written research reports and so on could be assessed by teachers in schools.*²⁵⁰

Risks

²⁴⁵ Hansard, 1 October 2013, Ms Georgie Richards and Mr Jayden Parsons

²⁴⁶ Hansard, 1 October 2013, Mr Lynton Hurt, p5

²⁴⁷ Ibid, Ms McEinery, p5

²⁴⁸ Hansard, 1 October 2013, p5

²⁴⁹ Submission 68, Mr Leon Perry

²⁵⁰ Hansard, 5 June 2013, Dr Gabrielle Matters, p15

Ensuring no disincentive to realising the benefits of school-based assessment – that is, the level of student learning it supports and the professionalisation of teaching it promotes – is an important consideration in any move to implement an external exam for any part of senior assessment.

There are concerns expressed by some submitters that external exams disadvantage some populations – students in smaller rural and regional schools, according to one teacher, because they are more likely to have less experienced teachers.²⁵¹ However, other teachers have commented that students at rural and remote schools are disadvantaged by the current school-based approach to assessment, as the less experienced teachers are setting and marking their assessment tasks; and those teachers have less opportunity for the professional development afforded by the moderation panel process.²⁵²

External exams are not without potential problems in terms of validity. This would particularly arise where a pen and paper exam is not ‘fit for purpose’ for assessing whether a student has achieved the requirements of a curriculum that relate to practical elements, including extended research. In those cases, it would be expected an exam result would not necessarily correlate with the school’s assessment of performance.²⁵³ This would need to be considered where an external exam is used to validate a school’s assessment of a student’s achievement.

Construction of tests and exams must also be done to ensure they are “*sensitive to teaching rather than focused coaching*”²⁵⁴ if they are to overcome any alleged ‘cheating’ or unfair tutoring support issues, and work to promote teaching and learning. The same can be said for any other assessment task, including extended investigations (see Chapter 9).

A risk identified by Masters and Hill in 1988 was that if external exams are set for some subjects, that other subjects become seen as less rigorous or less valued; and/or that the syllabus becomes limited (potentially ‘dumbed down’) and only the areas that are readily measured by exams, get taught.²⁵⁵ This is almost the mirror argument to that being made strongly by some submitters to this inquiry and outlined above: that is, that current assessment methods and in particular extended investigations as they are presently framed, result in insufficient focus on content knowledge because content knowledge is less readily assessed that way.

However another teacher pointed out that:

*With external exams, teachers can't teach the exam because they don't know what is on the exam, so they teach what's in the syllabus, and they teach the entire syllabus. Which, not surprisingly, is what they are supposed to do.*²⁵⁶

And as Ms Young indicated in respect of the IB system, students learn the whole syllabus, as they do not know which parts of it will be tested in the final exam.²⁵⁷

²⁵¹ Hansard, 10 July 2013, Mr Steve Ryan. See also submission 43

²⁵² Submission 64, name suppressed, p3

²⁵³ Hill et al, 1997. Reforming the Assessment of Student Achievement in the Senior Secondary School. In *AJE*, 32 (3), pp274 - 286

²⁵⁴ Stanley, 2012, p2

²⁵⁵ Masters and Hill, 1988

²⁵⁶ Submission 52, Mr Rex Boggs, p2

²⁵⁷ Hansard, 1 October 2013, Ms Young

In having an external exam, it would also be important to ensure that the school based component of assessment did not simply become preparation for the exam – a particular risk where school based assessments are adjusted in accordance with the exam anyway, as in Victoria (so, the exam is seen as having greater validity than the school-based components of assessment).

7.2 Teaching to the test

What is assessed or reported becomes the focus of teaching and learning. On the one hand, the committee has heard, content and procedural knowledge are not clearly assessed under present methods, and are therefore not adequately taught and learnt. On the other hand is the concern raised through the inquiry about ‘teaching to the test’. This concern is that because an exam is only ‘fit for purpose’ for measuring achievement against certain criteria within a syllabus, and an exam is the major contributor to the student’s overall grade in a subject, then the aspects of the curriculum that are not measured by it (eg conducting a scientific investigation, or applying mathematics to a relevant real life situation) will not be taught (or learned).

The students who met with the committee considered that exams did allow for elements of higher order thinking. Ms Young, who completed the IB, said that:

*Every test that I did at the end of grade 12 is an external and the questions definitely allowed me to think above and beyond... With all our external examinations, there were multiple ways you could go about it and there were multiple directions. I think it did allow for higher level thinking, because if you could only answer it at the basic level you are only going to get two of three points, but if you really apply yourself, if you really applied the knowledge and thought right back through your education, you were able to get the higher points,*²⁵⁸

A number of submitters consider the current system of 100% internal assessment leads to teachers ‘teaching to the test’. For example, Mr Rex Boggs, a mathematics teacher with over 40 years of experience, who has also been a district panel chair and head of department, told the committee that:

*With external exams, teachers can't teach the exam because they don't know what is on the exam, so they teach what's in the syllabus, and they teach the entire syllabus. Which, not surprisingly, is what they are supposed to do. Ironically, there is far more "teaching to the test" in the QSA senior courses than in courses assessed with an external exam.*²⁵⁹

A secondary school teacher considers that “[i]nternal Assessed Assignments and Examinations result in teachers teaching to the test because they have viewed the test.”²⁶⁰

A chemistry and biology teacher, who is also a head of department and an examiner for the International Baccalaureate Organisation (IBO) considers that internal assessment makes it easier for teachers to ‘teach to the test’:

²⁵⁸ Hansard, 1 October 2013, p8

²⁵⁹ Submission 52, Mr Rex Boggs, p2

²⁶⁰ Submission 78, Mr Andrew Jackson, p1

*Some claim external assessment means that teachers teach to the test. In fact, the opposite is true. Internal assessment, where the teacher knows the test questions in advance, makes it much easier to fall into teaching to the test.*²⁶¹

Another teacher explained why they consider ‘teaching to the test’ commonly occurs:

*Breadth of topic coverage versus depth. To write questions that give sufficient depth of knowledge in Chemistry to enable students to answer an A standard question that is ‘complex and challenging’ (each criterion has its own version of this requirement) across 9 sub-criteria means that ‘teaching to the test’ commonly occurs.*²⁶²

Committee comment:

All of the evidence heard by the committee supports the argument for assessment methods and processes that are ‘fit for purpose’. This suggests a range of methods and processes are required to measure the different aspects of learning, and fulfil the different functions that assessment has.

The argument used by the QSA to support having a range of assessment tasks, could also be applied to support having a range of assessment types, including an externally set exam, for senior mathematics, chemistry and physics. The committee does not see any reason for the same model of assessment to be used for every senior subject.

In the context of standards-based assessment, the committee also sees the benefit of an element of norm-based assessment being built into subject based assessment. It is there anyway, albeit through a separate process, for students who seek to enter university; and it is of benefit to potential employers as well as universities – not to mention the student themselves – to see a student’s achievement in relation to other students. The QCS test could become less necessary as a result, with cost-savings directed towards running the subject-based exams more broadly than they are run at present.

Teaching to the test is only an issue the test does not test the whole syllabus, and there is no other assessment method in place to ensure the whole syllabus is taught and learnt.

The committee accepts that assessment at the school level is a valuable component of an assessment system. Teachers are professionals and have a good knowledge of their students, and thus are well placed to design relevant lessons, and to assess the achievements of their students. At present, schools determine the timing and nature of the tasks students undertake so that teachers can assess their achievement. Assessment of the four to six summative assessment tasks for each senior subject occurs at four to six points over Year 11 and Year 12. It is acknowledged that this approach can lead to a sustained intensity of effort over the senior program which can overly stress some teachers and students.

However one final exam as the only opportunity to demonstrate achievement of a senior course of study is even more problematic. The committee believes that better balance is required.

Some less time-consuming school-based summative assessment tasks, contributing less to a student’s overall mark for a subject than at present, along with an externally set assessment

²⁶¹ Submission 184, Name suppressed, p3

²⁶² Submission 143, Name suppressed, p4

component to promote teaching and assessment of content knowledge, would seem to provide a reasonable balance between ensuring teaching and learning of the entire syllabus, and manageability for teachers and students.

Retired teacher Mr Leon Perry makes a suggestion about how to incorporate an externally set, standardised exam for these subjects within the current school-based assessment and moderation system:

*We have a de facto external exam in Queensland, it's called the Core Skills Test. The progression from school-based assessment to an external exam in Chemistry, Physics and Senior Mathematics is not all that difficult. The existing structure of QSA Review Panels lends itself to (a) having the external exams marked within each school according to QSA assessment schemata, (b) schools submitting samples of "marked" or assessed exam responses to Review Panels for confirmation of assessed levels of student achievement, etc.*²⁶³

In that scenario, however, or for any assessment scenario, it would be necessary to ensure the syllabus sufficiently described the criteria and standards to support consistent assessment.

Recommendation 1:

The committee recommends that schools should retain the ability to determine the timing and nature of summative assessment tasks, with the syllabus specifying an upper limit on the number of extended assignment tasks; and a reduced contribution by inquiry-based tasks to a student's overall achievement grade (see also Recommendation 9).

Recommendation 2:

The committee recommends that an external exam count for 50% of a student's overall achievement mark in senior mathematics, chemistry and physics to:

- a) ensure an appropriate focus on content knowledge which, of the three criteria for each subject, is the one most readily testable by an exam task (and what is tested, gets taught)
- b) ensure an element of commonality in respect of content knowledge around the state, which makes comparing student scores more meaningful for employers and universities
- c) promote confidence in the validity of all of a student's final mark for a subject by increasing the likelihood of consistent assessment practices against a common task.

Recommendation 3:

The committee recommends that the syllabus documentation specify the goals of senior mathematics, chemistry and physics courses, in terms of post-school directions; and explicitly advise how the courses will achieve those.

²⁶³ Submission 68, Mr Leon Perry, p3

Recommendation 4:

The committee recommends that the subject-based external exam for mathematics, chemistry and physics be used to scale school-based assessments, in recognition of the fact that exams provide a valid assessment of a student having ‘the basic’ content and procedural knowledge in the subject area and that the criteria relating to this knowledge should be a primary determinant of the student’s achievement level in these subjects.

8 Standards-based assessment

Standards-based assessment operates on the basis that if the assessment criteria for a subject and the features of each standard of achievement for those criteria are carefully enough defined, then performance can be judged accurately.

8.1.1 The criteria

By and large, criticism of the standards-based approach to assessment in these subjects seems to be more about the way they are expressed in the syllabus, and the relative focus on each of the three criteria for each subject, than the standards approach per se.

Some submitters do express concerns with the criteria themselves, such as Dr John Ridd, who advocates retaining only the ‘Knowledge and Procedures’ criteria in physics²⁶⁴, as does Professor Peter Ridd²⁶⁵ who believes the current system is ‘assessing irrelevant criteria’. Teacher Mr Steve Ryan, while generally supportive of the school-based and standards-based assessment system, considers that the ‘Communicating and Justification’ criteria for mathematics B is unnecessary and should be implicitly covered by the other two criteria.²⁶⁶ Others also raise concern with the ‘Communicating and Justification’ criteria for mathematics B.²⁶⁷ One pro forma type submission that was made by a number of people advocated that:

*The Evaluating and Concluding category shows that the criteria were designed with too much emphasis on the writing skills of the students. Get rid of the EC category.*²⁶⁸

The more strongly expressed view in submissions to this inquiry was that the descriptions of what is required to achieve each standard are subjective and unclear, exacerbating an already fairly high degree of subjectivity in their application by teachers, which decreases the validity and reliability of assessments and makes it more important there be external and consistent validation. While this concern may relate to standards-based assessment in general, and not just for the subjects within scope for this inquiry, the committee is not aware of similar concerns being raised for other subjects (but notes it did not expressly seek to identify any such concerns). It is clear though that the descriptive nature of the standards is viewed as particularly problematic in the mathematics and science fields by some who teach those subjects. Terms like ‘vague’, ‘subjective’, and ‘meaningless’ are repeatedly used to describe them, in submissions.

There are widely diverging views evident amongst teachers, however.

Where the criteria and standards of achievement are not clearly understood, it is argued, the likelihood of a high level of variation in interpretation reduces the validity of the assessment. Yet other teachers indicate that the assessment standards “clearly articulate the aspects of a student’s work required to achieve at a particular level.”²⁶⁹

²⁶⁴ Submission 105

²⁶⁵ Submission 98, and a large number of pro forma submissions

²⁶⁶ Submission 43, and see also Hansard, 10 July 2013, p13

²⁶⁷ Submissions 1, Doug Goldson; 163, 187 (names suppressed), and 207, Mr Trevor Barrett

²⁶⁸ For example, Submissions 269, 285

²⁶⁹ Submission 13, Mr Matthew Hughes

Some teachers feel that the current standards make it difficult for them to give accurate feedback to students about their work. Others say that the detailed “criteria ...allow me to give specific feedback that certainly doesn’t involve saying something to the effect of ‘well, you just need to get a few more things correct’”.²⁷⁰

Teacher Mr Robert Hill is concerned that the standards do not specify that a student is required to correctly solve a mathematical problem in order to achieve a good grade:

*In fact, if one looks closely at the criteria (‘use of problem-solving strategies to interpret, clarify and analyse problems to develop responses from routine simple tasks through to non-routine complex tasks in life-related and abstract situations’ (maths B, Modelling and problem solving), there is actually no requirement for the student to have successfully solved the problem! It could be said that that requirement is implied – but in fact it is not stated. This is one of the biggest weaknesses of the current criteria – the requirement to accurately and completely solve problems is not generally there if one strictly applies the criteria – one presumes that you are supposed to strictly apply the criteria! If this one rigorous requirement was put in place, that of requiring students to actually demonstrate their ability to accurately and completely solve problems, many of the current criteria would be redundant and life would be so much clearer and simpler and so much stress and time-wasting would be spared. Incidentally this argument equally applies to physics and chemistry too – there is little or no requirement for students to actually get things right! There is a crying need for the criteria themselves to be reviewed.*²⁷¹

8.1.2 Subjectivity

Dr Matthew Dean commented that:

*Looking at the table of paragraphs for Maths B and Maths C, the K&P Criterion for example, we see the words ‘routine’, ‘non-routine’, ‘life-related’, ‘simple’, ‘complex’ and ‘appropriate’ are used to distinguish the grades. All of these words are subjective. What is considered routine, simple or appropriate by one person, may be unusual, complex or inappropriate to another. The interpretation of these words varies from person to person. Hence, they are subjective. The same goes for ‘life-related’ - whose life are we referring to? It follows that any meaning these paragraphs may have, varies from person to person, i.e. they are subjective, not objective.*²⁷²

Echoing Dr Dean’s comment, another submitter considered the definitions of routine and non-routine are also considered to be unclear.²⁷³

As has been noted earlier in this report, a level of subjectivity in assessment is inevitable. But, it is clear to the committee that in the traditionally precise area of mathematics in particular, some teachers, parents and students struggle with the level of subjectivity inherent in the current syllabus.

Professor Noel Meyers submitted that:

²⁷⁰

Ibid

²⁷¹

Submission 20, Mr Robert Hill

²⁷²

Submission 28, Dr Matthew Dean

²⁷³

Submission 42, name suppressed

*By more thoroughly articulating and guiding the principles and the underpinning cognitive challenges that we are providing for students, it is my view that we could significantly enhance the quality of their learning and also the quality of the standards that could be communicated to the public... When that has been done elsewhere, my understanding from the literature is that it significantly enhanced the quality of student understanding and student performance.*²⁷⁴

Examples provided to the committee of potentially ambiguous elements of the syllabus include:

- The use of ‘must’, ‘should’ and ‘might’ in the syllabus documents, in respect of what is to be taught and assessed. The QSA has advised that these terms are used very deliberately to denote what is compulsory, what is best practice, and provide illustrative examples, respectively.
- The only difference between an ‘A’ standard and a ‘B’ standard being the words ‘and’, instead of ‘or’. See, for example, the Chemistry exit standards in respect of the Knowledge and conceptual understanding criteria. An ‘A’ standard can be awarded where the student work has the following characteristics: reproduction and interpretation of complex and challenging concepts, theories and principles; while a ‘B’ standard can be awarded for reproduction and interpretation of complex or challenging concepts, theories and principles. Similarly, some teachers report that the A and B exit standards for Mathematics C are difficult to distinguish. Some teachers report that this level of detail is insufficient for them to readily assess students’ work, which must impact on the validity of the assessment (this is discussed further in Chapter 10). The relevant section²⁷⁵ is illustrated below:

6.9 Standards associated with exit criteria

Criterion	Standard A	Standard B
Knowledge and procedures	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> recall, access, selection of mathematical definitions, rules and procedures in routine and non-routine simple tasks through to routine complex tasks, in life-related and abstract situations application of mathematical definitions, rules and procedures in routine and non-routine simple tasks through to routine complex tasks, in life-related and abstract situations numerical calculations, spatial sense and algebraic facility in routine and non-routine simple tasks through to routine complex tasks, in life-related and abstract situations appropriate selection and accurate use of technology knowledge of the nature of and use of mathematical proof 	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> recall, access, selection of mathematical definitions, rules and procedures in routine and non-routine simple tasks through to routine complex tasks in life-related and abstract situations application of mathematical definitions, rules and procedures in routine or non-routine simple tasks, through to routine complex tasks, in either life-related or abstract situations numerical calculations, spatial sense and algebraic facility in routine or non-routine simple tasks, through to routine complex tasks, in either life-related or abstract situations appropriate selection and accurate use of technology

Table 4: Standards associated with exit criteria.

²⁷⁴ Hansard, 10 July 2013, Professor Noel Meyers, p3

²⁷⁵ QSA, 2008 Mathematics C syllabus

- Terms such as ‘assessment techniques’, ‘assessment instruments’, ‘categories’, ‘dimensions’, ‘standards’, ‘criteria’ (and even assessment ‘methods’ and ‘processes’ as used in the terms of reference for this inquiry) do not appear to be used consistently across all syllabus documents and their supporting and reference material.
- The definition of ‘sound’, in terms of a standard of achievement (a ‘Sound Achievement’ or SA score) is not consistent with the term ‘sound’ as in common use. This has been identified elsewhere in this report as it is in part a function of the equal weighting of all three criteria in these subjects, as well as the marking regime.

Committee comment:

While the concerns about the criteria themselves relate to the question of whether the syllabus has sufficient emphasis on content and procedural knowledge, the existence of the criteria is taken as a given by the committee and in general terms, the committee accepts that higher order skills are important components of education in the 21st century. However, the focus on content knowledge in relation to the other two criteria for each subject could be reconsidered.

In doing this, the risk that having a greater emphasis on the content knowledge could ‘dumb down’ the senior level syllabus would need to be managed. For example, multiplication tables were cited as lacking in first year university students, but these should be taught well before senior level. This relates to the issues identified in Chapters 5 and 6, whereby it is clear that participation rates and performance are largely determined well before senior level studies. Strategies therefore might need to target the years before senior.

With regard to interpretation and subjectivity, the committee questions whether descriptive standards can, or should, in fact be ‘strictly applied’ to the criteria other than content and procedural knowledge; and whether correctly solving a problem is in fact implicit in the standards. Nevertheless, if they are causing confusion for some teachers, that would seem to be reason to clarify them. Certainly other jurisdictions provide more detail about the features of each standard, which seems to support teachers.

Criticisms about the subjectivity of the standards could be levelled at any other subjects taught at the senior level, such as English Literature, yet there do not appear to be concerns being raised about subjectivity in those areas. It is acknowledged, though, that these were not within scope for this inquiry and the committee has not explicitly sought advice on whether there are similar concerns in those subjects.

It is apparent to the committee that the standards for senior mathematics, chemistry and physics in Queensland could be more clearly articulated. The committee has considered both the evidence taken from witnesses and a review of the Queensland syllabus standards alongside the standards as articulated in syllabus documents from other jurisdictions. A level of detail greater than provided for some other subjects may be more necessary for mathematics, chemistry and physics, given the nature of these subjects which are grounded in objective, precise formulae.

The committee recognises that a level of subjectivity is inherent in any assessment process, and that several reviews have found that in Queensland, there is a high level of consistency between assessments by different teachers of the same pieces of work. It is unclear whether that is true specifically for mathematics, chemistry and physics though, or whether

it applies more generally to subjects taught by teachers who are more used to assessing in a standards-based context.

Recommendation 5:

The committee recommends that research be undertaken into whether there are differential impacts of standards-based assessment for humanities and mathematical and scientific subjects.

8.1.3 Interpretation and application

Standards-based assessment assesses achievement against the syllabus content. It does not have to finely rank students, though a degree of ranking is undertaken at the school level (over a spread of 15 levels). When the syllabus document should be explicit about what knowledge or capabilities must be demonstrated for any given level of achievement against the syllabus, it should be clear what the student can do, or not do.

There are complaints from some academics that grades like 'VHA', 'SA' don't allow them to understand what a Queensland senior graduate knows and doesn't know.²⁷⁶ Responding to these complaints, Professor Peter Fensham said that:

*I think we need to get away from the notion that a quantitative score has a greater reliability to tell us that a student can do a range of things than a qualitative score, because you can take a common test and get 60 per cent and it can be made up of all sorts of different combinations from the various questions that are asked. So the 60 per cent may seem to be quite a good score, but it will mask the fact that on some questions you have a very low score and other questions you have a high score.*²⁷⁷ (See also Chapter 11).

Following is Queensland's 'standards associated with exit criteria' for chemistry, from which teachers have to derive criteria sheets for each of their assessment tasks:

Criterion	A	B	C	D	E
<i>Knowledge and conceptual understanding</i>	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> reproduction and interpretation of complex and challenging concepts, theories and principles comparison and explanation of complex concepts, processes and phenomena 	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> reproduction and interpretation of complex or challenging concepts, theories and principles comparison and explanation of concepts processes and phenomena 	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> reproduction of concepts, theories and principles explanation of simple processes and phenomena 	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> reproduction of simple ideas and concepts description of simple processes and phenomena 	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> reproduction of isolated facts recognition of isolated simple phenomena

²⁷⁶ Eg forum

²⁷⁷ Hansard, 1 May 2013. Professor Peter Fensham, p7

Criterion	A	B	C	D	E
	<ul style="list-style-type: none"> linking and application of algorithms, concepts, principles, theories and schema to find solutions in complex and challenging situations. 	<ul style="list-style-type: none"> linking and application of algorithms, concepts, principles, theories and schema to find solutions in complex or challenging situations. 	<ul style="list-style-type: none"> application of algorithms, principles, theories and schema to find solutions in simple situations. 	<ul style="list-style-type: none"> application of algorithms, principles, theories and schema. 	<ul style="list-style-type: none"> application of simple given algorithms.
<i>Investigative processes</i>	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> formulation of justified significant questions/hypotheses which inform effective and efficient design, refinement and management of investigations assessment of risk, safe selection and adaptation of equipment, and appropriate application of technology to gather, record and process valid data systematic analysis of primary and secondary data to identify relationships between patterns, trends, errors and anomalies. 	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> formulation of justified questions/hypotheses which inform design and management of investigations assessment of risk, safe selection of equipment, and appropriate application of technology to gather, record and process data analysis of primary and secondary data to identify patterns, trends, errors and anomalies. 	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> formulation of questions and hypotheses to select and manage investigations assessment of risk, safe selection of equipment, and appropriate application of technology to gather and record data analysis of primary and secondary data to identify obvious patterns, trends, errors and anomalies. 	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> implementation of given investigations safe use of equipment and technology to gather and record data identification of obvious patterns and errors. 	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> guided use of given procedures safe directed use of equipment to gather data recording of data.
<i>Evaluating and concluding</i>	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> analysis and evaluation of complex scientific interrelationships exploration of scenarios and possible outcomes with justification of conclusions/recommendations discriminating selection, use and presentation of scientific data and ideas to make meaning accessible to intended audiences through innovative use of range of formats. 	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> analysis of complex scientific interrelationships explanation of scenarios and possible outcomes with discussion of conclusions/recommendations selection, use and presentation of scientific data and ideas to make meaning accessible to intended audiences in range of formats. 	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> description of scientific interrelationships description of scenarios and possible outcomes with statements of conclusion/recommendation selection, use and presentation of scientific data and ideas to make meaning accessible in range of formats. 	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> identification of simple scientific interrelationships identification of scenarios or possible outcomes presentation of scientific data or ideas in range of formats. 	<p>The student work has the following characteristics:</p> <ul style="list-style-type: none"> identification of obvious scientific interrelationships statements about outcomes presentation of scientific data or ideas.

Table 5: Queensland's 'standards associated with exit criteria' for chemistry.

The direction provided by the syllabus in Queensland places a considerable onus on teachers to interpret, apply and explain the criteria and standards to students and parents; and the

fact that this occurs at an individual teacher and school level, often by a teacher without qualifications in the discipline (see Chapter 15), is clearly a cause of significant frustration for some teachers. If teachers are not confident about their ability to apply the criteria and standards in assessing an assessment task, there will certainly be implications for reliability and validity:

If it is going to be reliable, it has to give you the same outcome regardless of which teacher does it. While we have to rely on the judgement of teachers to put the ticks in the right place, further, we need to rely on them to average them correctly. But it seems that there are guidelines to say, you must average in this way, use your discretion within this box.²⁷⁸

One teacher contrasted the current (2007) physics syllabus with the one it replaced:

.... the 1995 syllabus details the topics to be studie[d], learning experiences, resources and most importantly the core material to be studie[d], the minimum depth of treatment of the core and ideas for extension material. This is done on pages 14 – 31. On page 12 were listed the subject matter topics, the time to be allocated to teaching these topics as well as the number of hours to be spent on extension topics – where the school / teacher could extent students in areas most relevant to the school population etc. There is simply no comparison between the two syllabi: Under the 1995 syllabi you could be certain of what Physics a student had been exposed to and to what depth. Students successfully exiting the 1995 syllabus would have a good and detailed foundation in Physics and what that foundation was could be clearly seen in the syllabus. Now since the 2007 syllabus was implemented at best you might have a vague idea of what a student has covered in their Physics class but to what minimum depth and minimum set of the knowledge of Physics who would know? No one! Every school basically does what it likes with a vague general framework. Thus the first problem is the whole content basis of Physics is built on shifting sand.²⁷⁹

The former syllabus sounds not unlike the current New South Wales and Victorian syllabi for the subjects in question. The New South Wales HSC syllabus for physics, for example, is much more prescriptive than the Queensland counterpart, and schools are still required to develop their own assessment programs within fairly detailed parameters.

The author of submission 121 identified:

*Descriptors such as ‘correct, precise, accurate, justified’ are used in the Victorian criteria but are rare or absent in the Queensland standards. When Queensland teachers have tried to incorporate a few additional words into the criteria in their instruments to improve clarity for students and those having to mark the work (as we were told we could when the syllabuses were introduced) we have been reprimanded by panel – **it appears that accuracy and precision are not valued attributes of student work in Queensland**. Some things are very difficult to interpret in the Queensland criteria, for example a ‘D’ is ‘identification of*

²⁷⁸ Hansard, 1 May 2013, Professor Lindsay, p4

²⁷⁹ Submission 163, name suppressed

*simple scientific interrelationships’ and an ‘E’ is ‘identification of obvious scientific interrelationships’.*²⁸⁰

The complaint that it is not possible to tell what a student knows or does not know from the exit achievement awarded, suggests that the criteria and the standards are not clearly defined, and that not enough information about performance in respect of each of the criteria and the relationship to specific course content, including weighting, is available to universities or employers. Further, the way that an exit level of achievement is calculated can mean a student receives an assessment of SA overall, while having received a ‘C’ level for two criteria, and a ‘D’ for one – which might be the content knowledge criteria (see also Chapter 10).

*Year 11/12 results can be, and often are, a reflection of how well the assignments were done. We have seen earlier that the increases in the percentages getting Very High and High ratings in Physics may be a consequence of better results on ‘assignments’ than on rigorously set examinations. Of course the assignments and their results are of zero significance for performance at university Maths.*²⁸¹

*I came to the conclusion that a Sound Achievement in Maths B is highly variable. Yet this is a standard entry requirement for many Science and Engineering degrees in Queensland Universities. It is reasonable to expect that students with an SA grade can routinely carry out standard procedures.*²⁸²

If the syllabus were sufficiently well defined and the relationship between course content and the standards and criteria were obvious, it would be fairly clear what each exit achievement level (VHA, HA, SA, etc.) means in terms of what the student knows and does not know.

As Professor Royce Sadler advised the committee:

*We do need to make sure that when we say sound achievement it agrees with what people think is sound in the normal sense of the word. So those kinds of things we really must attend to so that misconceptions do not develop.*²⁸³

Reporting on a group discussion at the expert advisory forum, Professor Merrilyn Goos said:

We also acknowledge that young people are different now from the way they were 20 years ago. The world is a different place. Technology has changed the way that we access information, and of course information is not the same as knowledge. So we know that we need to change the way that we teach students where ‘we’ mean teachers in schools and in universities. So we came back to what we think is a fairly key question about assessment: does it provide us with confidence that students when they leave school know enough mathematics, chemistry and physics to be able to succeed at university? So we tried to unpack that a little bit more. We do not think it is possible to guarantee that every student leaving school with the same apparent level of achievement knows exactly the same amount of stuff or to the same depth or the same quality, and

²⁸⁰ Submission 121, Name suppressed, p15

²⁸¹ Submission 105, Dr John Ridd, p15

²⁸² Submission 206, Dr Tony O’Connor, p1

²⁸³ Hansard, 1 May 2013, Professor Royce Sadler, p11

*that has never been the case. But we would like to be confident that school leavers when they get to university have some common foundational knowledge upon which we can build and they are able to acquire new knowledge at university.*²⁸⁴

Committee comment

A recommendation given to the committee by Dr John Ridd related to the need for a syllabus to ‘*set clear and high expectations of what students are expected to achieve*’.²⁸⁵

While the QSA claims that the current syllabus does just that: *Achievement standards are fixed reference points used by all schools to describe how well students have achieved the objectives in the syllabus*²⁸⁶, it is clear to the committee that the level of detail provided about each standard does not support their use as fixed reference points.

The committee acknowledges the benefits of standards-based assessment, particularly in respect of the support that method provides for development of the higher order skills necessary for a modern, growing economy. However it is clear that the syllabus documentation as it stands now is not well understood by all who need to understand it.

Recommendation 6:

The committee recommends the syllabus documentation be provided with more detail about standards of achievement against each criteria, to support teachers in their task of assessing students’ standards of achievement against each criteria.

²⁸⁴ Hansard, 1 May 2013, Professor Merrilyn Goos, p5

²⁸⁵ Submission 105, Dr John Ridd, p16

²⁸⁶ Hansard, 6 March 2013, Mrs Patrea Walton, p2

9 Assessment tasks

Schools determine the type and number of summative assessments set for students, within the parameters mandated by the syllabus documents for each senior subject. Four to six pieces of work are required in physics and chemistry, and four to ten in the mathematics subjects.

The four to six assessment tasks mandated in the Queensland chemistry and physics syllabi include the following types of tasks:

- Extended experimental investigations (EEl)s (Chemistry, Physics) – one in each of Year 11 and Year 12 is mandated. These have a recommended word limit of 2500 words by the end of the course
- Extended response tasks (Chemistry, Physics) – not mandated
- Supervised assessments (typically tests) – mandated.

Mathematics B and C require four to ten assessment tasks from the following:

- Extended modelling and problem solving task (maths B&C) – two of either this or a report (below) mandated in Year 11 and in Year 12
- Reports – an extended response to a practical or investigative task
- Supervised assessments (typically tests) - mandated.

The QSA provides support material to assist schools in their programming, with the aim that students are not faced with multiple assignments due for completion or teachers with work requiring assessment at the same time; and word limits to ensure that the tasks are not bigger than they need be. Practice at the school level however, does not always seem to match the intent of the QSA.

Assessment tasks are developed and assessed at the school level, with moderation of assessment by panels of teachers from other schools within the district, and then the state, to achieve comparability.

In Queensland, comparability – which is central to ensuring validity and reliability – is sought through use of a common syllabus and assessment approach by all schools, as well as by expert and/or peer review in moderation panels (see Chapter 11, Moderation).

The concept of ‘fitness for purpose’ is central to the discussion about the validity and reliability of assessment. The most valid and reliable form of assessment must be determined by what it is that is being measured. As ACER points out:

Domain-appropriate assessment methods in learning areas such as dance and drama include direct observations of student performances. Domain-appropriate assessment methods in learning areas such as art and technology include observations and evaluations of the products of student work. Any attempt to assess learning in domains such as these using only paper and pen assessments would lack ‘construct’ validity.

*In other words, the chosen assessment method would be inappropriate to the domain and would be incapable of providing valid information about where students are in key aspects of their learning.*²⁸⁷

In senior mathematics, chemistry and physics in Queensland, assessment tasks aim to cover the three assessment criteria for each subject. Each assessment task will address the criteria to varying degrees, focusing on the key concepts which are outlined in the syllabus. To take the example of chemistry, these include key concept S1 – all matter is composed of atoms; key concept R2 – chemical reactions involve energy changes, among seven key concepts in total. Teaching of the key concepts is to be structured by a school in developing its work program, so that the program develops in complexity, scope and depth over the two year senior program.

The extended investigation, extended response and problem solving assessment tasks in senior mathematics, chemistry and physics have been a primary focus for this inquiry.

Generally speaking, most submitters considered that inquiry and experimentation are good ways of learning, and are in fact fundamental to science.

Chemistry teacher and experienced panellist Mr Nick Dubravcic advised:

I truly believe that EEI and ERT tasks provide students with the opportunity to use their preferred learning styles to demonstrate their ability within a specific subject. Multiple choice and short answer questions have their place in all subjects, but I do not believe they lend themselves to students demonstrating the depth of conceptual understanding that can be expressed in a research task. I pride myself in being able to teach my students to think, to problem solve and to be able to show their understanding of concepts, including links between concepts in their explanations and justifications. These are not possible in multiple choice and short answer tests. Although I do agree that time is a limiting factor in Years 11 and 12, I do believe that one EEI per year is achievable and that it provides students with a contextual anchor to what may be a highly conceptual and difficult to imagine/understand world of Science or Mathematics.

A concern was expressed by a number of teachers that the prescribed word length of these extended assessment tasks limit teaching and learning of all the areas that should be covered by the syllabus, because so much time has to be spent on covering one area of content in great depth. For example:

*Science is an experimental science and in high school chemistry students should have the opportunity to develop a wide range of manipulative skills. EEI's reduces the variety of experiments that can be done since time is taken up with one experiment rather than many different experiments.*²⁸⁸

Views were also expressed about the contribution of these extended assessment tasks for university study, with some considering students are under-prepared in terms of content knowledge:

²⁸⁷ Submission 58, ACER
²⁸⁸ Submission 64, name suppressed

*...assessment in schools acts as a filter in so far as assessment instruments expose inadequacies in students abilities and talents. Ameliorating the impact on student sensibilities by altering the Chemistry and Physics assessment instruments and techniques that remove the use of marks is misguided. It postpones the inevitable reality check and narrows the window of opportunity for students to change to subjects more aligned with their capabilities and talents. If that reality check occurs in a first year university science course, the result is disastrous. Better that it occurs in the first term of a school senior science subject.*²⁸⁹

Ultimately, the concern is that in mandating extended assignments, in effect the syllabus focuses on higher order skills at the expense of time to teach and learn the knowledge and procedures that underpin these subjects.

*EELs have a tendency to focus on one specific area and can actually lower student interest when the topic does not interest them. This has been recognised by Victorian educators who changed their syllabuses so as to allow smaller more diverse practical activities (SEIs).*²⁹⁰

Dr John Ridd also endorsed a larger number of shorter practical assessment tasks, stating that:

*In the Sciences there must be a substantial increase in the number of traditional Practicals. Each to be written up in standard scientific manner and brief.*²⁹¹

Dr Ridd also commented that:

*The vast Extended Experimental monsters use up so much time that there are few other Practicals done at all. Hence they gain almost no idea of how to do a prac, what to look for if things seem to go adrift, where errors may occur.*²⁹²

Other academics from the mathematics and science-focussed disciplines at Queensland universities were strongly supportive of the use of extended investigations in these subjects. Professor Noel Meyers commented:

*Extended investigation provides students with the opportunity to learn science by doing science. There is no more powerful way in which to create the next generation of innovators and practitioners of science, engineering and in the health disciplines that this particular strategy. I would suggest also that the current standards based criteria reference assessment provides guidance and intellectual scaffolding for the students as they progress through completing these extended investigations. So they kind of have an expert in their pocket in order to make their understandings real and meaningful to them.*²⁹³

A number of other academics were similarly supportive.²⁹⁴

²⁸⁹ Submission 68, Mr Leon Perry

²⁹⁰ Submission 121, Name suppressed, p3

²⁹¹ Submission 106, Dr John Ridd, p17

²⁹² Submission 106, Dr John Ridd, p14

²⁹³ Hansard, 10 July 2013, Professor Noel Meyers, p 2

²⁹⁴ Eg Submission 250, Dr Anton Rayner and Dr Gwen Lawrie

And others, also arguing against the use of extended assessment tasks, indicate that students will not undertake this sort of work until well after first year at university so the considerable effort they impose is unnecessary:

*These university disciplines do not value this long written assessment (first year university experimental write ups are relatively small, and students are penalised if they exceed the prescribed number of words). It would be far better if school students worked on numerical problem solving plus short experimental write-ups in the normal (concise) scientific style (NOT long essays).*²⁹⁵

This goes back to the question of whether these subjects should be aiming to prepare students for university, or whether they have broader goals including employment goals. As Dr Rayner and Dr Lawrie point out, what employers are looking for is skills rather than knowledge, “so it is essential to measure student outcomes in team-work skills, manipulative skills, and communication skills”.²⁹⁶

Students themselves expressed a range of views on extended assessment tasks. Generally, the students who have informed this inquiry indicated that they felt these tasks were appropriate but that the word limits were difficult to adhere to.

For example, recent former student Ms Fiona Hu advised:

*The word limit was achievable, however I found that often in the Discussion aspect of the EEI, it was always a struggle to remain within the word limit. I know that many of my friends who were high achievers found it hard to stay within the limit, as did I myself, as extra information that had been researched and wanting to be included in the discussion often was taken out due to the word limit.*²⁹⁷

And under-graduate, and recent senior school graduate Mr James Penfold said:

*In contrast [to essay writing], EEIs are extremely relevant to the pursuit of education in science, and prepare students much more thoroughly for professional practice. As such, any reform ought to allow for more frequent EEIs. That being said, EEIs are often group assessments, with relatively vague scopes of inquiry. Although these characteristics make EEIs even more like professional practice, it does make the fair assessing of EEIs more difficult. As such, I would recommend increasing the number of EEIs, but reducing their overall contribution to the student’s grades.*²⁹⁸

Like teachers, not all students agreed with extended assignments being used for assessment purposes at all. Mr Mitch Comben, a current Year 11 student, reflects the view expressed by students (and teachers) who do not support their use:

Assignment based assessment places constant stress on me and my friends and I believe the assignments get worse in year 12. I am often doing four assignments at any one time. The assignments are so time consuming, I often don’t have time to do my every day homework which I need to do to pass my exams. Assignments use up too much class and homework time. Many of my

²⁹⁵ Submission 98, Professor Peter Ridd

²⁹⁶ Submission 250, Drs Rayner and Lawrie

²⁹⁷ Submission 145, Ms Fiona Hu

²⁹⁸ Submission 223, Mr James Penfold

*friends get help with the assignments because the questions asked are too complicated for us to understand. Some students cheat by copying assignments, giving themselves an unfair advantage. This makes the results they achieve questionable.*²⁹⁹

The parent of three daughters who are in high school confirmed that her children's experience was similar:

*Assignments are a huge drain on students time and cause a lot of stress in our household and the work load is out of control at times. The criteria is often confusing and very subjective and I feel that they don't provide a valid indicator of the students achievements or knowledge of maths, chemistry of physics.*³⁰⁰

9.1 Comparability with other senior subjects

The assessment requirements for senior mathematics, chemistry and physics in Queensland appear to be comparable with those for other senior QSA subjects.

For example, student must complete five assessment tasks in English, three of which must be written (two under supervised conditions) and two oral or signed. Extended responses are to be 800- 1200 words in length.³⁰¹ Geography requires five to eight summative assessment tasks, including one report based on primary data or field work of 800 – 1000 words in length.³⁰²

Recent student Ms Fiona Hu commented:

*The workload of senior Maths, Chemistry and Physics was greater compared to the other subjects I studied only because a deeper understanding of these concepts for these subjects was required. Numerous topics were covered within physics and maths within a term, this therefore needed more time to focus and understand the content being taught. There was usually one major piece of assessment each term for each of these subjects (except maths that had both a knowledge paper and problem solving paper) which I found to be an adequate, manageable workload.*³⁰³

Another recent student, Ms Elizabeth Henley, said that:

*If I was to rank the workload of subjects I have taken in senior it would go something like the following (least to most): English, Maths B, Physics, Chemistry, Modern History, English Extension, Art. Keeping in mind this may also be because I understand Maths B, Physics and Chemistry well enough to get through the work quickly. What consumes time for me in any subject is the amount of research you would have to do for an assignment. English – almost none, Maths B – all learnt in class time, Physics and Chemistry – just for assignment introductions, Modern History and English Extension – way too much (fries the brain), Art – lots of time hands on.*³⁰⁴

²⁹⁹ Submission 150, Mr Mitch Comben

³⁰⁰ Submission 179, Ms Debbie Lovell, p1

³⁰¹ QSA, 2010, English syllabus

³⁰² QSA, 2010, Geography syllabus

³⁰³ Submission 145, Ms Fiona Hu

³⁰⁴ Submission 24, Ms Elizabeth Henley

9.1.1 Problems identified with extended investigation and problem solving tasks

A key question is whether the balance between breadth and depth of knowledge might need to be adjusted.

As we have seen, an explicit goal of the school-based assessment system in Queensland is to help ensure that assessment supports the learning process.

The question of whether the foundational skills have to be taught and learnt before a student can meaningfully be assessed on an extended inquiry task also seems to be central to this inquiry. The committee heard from a number of experienced, passionate teachers who praised the use of extended assessment tasks with an inquiry focus, as the inquiry is used to further generate the foundation knowledge.³⁰⁵

Extended inquiry tasks are in line with international recommendations with regard to increasing the relevance of science and mathematics to raise interest by students in studying these subjects.³⁰⁶

The majority of teachers who submitted to the inquiry recognised the value of these tasks as learning tools, and as a means of engaging students. However, as well as concerns about the time and effort taken to develop, undertake and assess them – workloads for students and for teachers – there were concerns expressed about the extent to which they contribute to a students' overall assessment. The following reasons were offered in support of a reduced contribution:

The criticisms not already addressed above are:

- They are biased against boys
- They are biased against population groups who may not have strong English language skills
- Unsupervised assessment tasks cannot be authenticated as the student's own work (and therefore these tasks have low validity as assessment tools)
- They are unnecessarily time consuming for students to complete, and teachers to set and assess
- Mental health of students and teachers is adversely affected.
- This section considers the concerns expressed about extended assessment tasks.

9.1.2 Sex discrimination

An assessment type that favours or disadvantages certain student groups impacts on the reliability of the assessment. Requiring written assignment type responses in mathematical and scientific subjects has been identified as disadvantaging boys:

*...by over-emphasising writing, which is traditionally weak in young males who are talented in quantitative subjects, boys are disadvantaged.*³⁰⁷

QSA data shows that it is not the case that the number of, or even the participation rates of boys compared with girls studying these subjects is declining.³⁰⁸ In fact all students'

³⁰⁵ Hansard, 6 March 2013, QSA briefing, Mr David Madden.

³⁰⁶ AIG, OCS, UNESCO

³⁰⁷ Submission 98, p10 Professor Peter Ridd. See also Submission 106, Dr John Ridd, pp8,14; Submission 182, Ian Pink

participation rates (as a proportion of OP eligible senior students) is declining, with girls' participation rate identified as a particular concern. The QSA also comments that:

*Regarding the achievement of females, relative differences in gender performance are complex, and related to a number of factors including such things as subject selection and learning styles, which are broadly correlated with gender. While the QSA acknowledges the challenges of developing assessments that cater for a range of abilities and learning styles, it is one of the strengths of school based assessment that it can accommodate differences in students in a way that a single mode of assessment, such as a one-off test, is unable to do.*³⁰⁹

The QSA provided more detailed advice about gender differences:

There is extensive scholarly research into differences in educational performances of boys and girls. A clear finding of this research is that differences do exist, but ascertaining what those differences are and finding reasons for them is difficult to achieve. Many authors express concern about simplistic representations of a "gender gap" in educational achievement that do not consider the complex mix of social, cultural, economic, developmental and educational factors that may equally contribute to achievement differences.

A number of established trends have been identified in literature related to gender differences and educational performance:

- Historically, girls have performed better academically than boys, except at the very "top" and "bottom" ends of distributions where there are a greater number of boys. For example, although girls, on average, achieve higher OPs than boys, more boys than girls obtain an OP1. It is very important to note that this phenomenon is not unique to Queensland. In New South Wales in 2012, there were 31 boys and 17 girls with the maximum ATAR of 99.951. In Victoria, there were 25 boys and only 12 girls with the maximum ranking.*
- Girls in single-sex schools tend to perform better academically, but it is difficult to separate this from socio-economic factors since single-sex schools are more likely to be independent schools.*
- Boys and girls may have different strengths or preferences for certain subjects but this does not necessarily create advantage or disadvantage for them as learners.*
- Boys and girls do perform differently in different types of assessment.*
- Despite lower overall academic performance at school, boys still continue to progress through the education system or labour force to better paid employment than girls.*

Many researchers focus on addressing perceived "gender gaps" through the need to provide quality education for all students, regardless of gender. Avoiding stereotyping, offering inclusive choices to engage all preferences and learning styles and having high expectations of both boys and girls are

³⁰⁸ Data supplied by QSA, also QSA website 'statistics' section; and see Chapter 5, Participation, in this report.
³⁰⁹ Submission 121, QSA, p25

*recommended for improving outcomes for both genders. Gender differences in achievement are important and require monitoring, particularly with regard to assessment methods. However, these differences in achievement must be kept in perspective, because they can be associated with social background.*³¹⁰

9.1.3 Language or literacy discrimination

Similar to the argument that assessment tasks that require English literacy disadvantage boys, is the argument that they disadvantage students who have English as a second language³¹¹ and other students for whom English literacy is not a strength.

However at the QSA briefing of the committee on 20 March 2013, teacher and panel chair Mr David Madden made the point that the detailed structure of scientific report formats can actually provide greater support to students with limited literacy skills; as can the fact that the responses do not have to be literary. In fact much of such a document will consist of graphs, tables, and other visual representations of data. In addition, the detailed nature of the task means that a teacher can work out whether the student does understand the issue or not, based on the logic demonstrated to reach conclusions, and not simply on the conclusion (or answer) itself as occurs in some other assessment tasks.³¹² This would allow the teacher to provide the additional support required to ensure the student does understand the skills or knowledge the task is aiming to assess.

The QSA also pointed out that having work programs set at the school level rather than centrally, means that work programs can ensure the particular needs of various groups of students are met with the subject matter chosen to reflect the contributions and experiences for all groups.³¹³

Another submission suggested an approach that would maintain validity and efficacy but minimise cumbersome procedures:

*One such approach that has been used for modelling tasks involving model formulation, making assumptions, solution of mathematics, interpretation, evaluation and/or refinement involves the construction of a poster as a report – with size limited to two sheets of poster paper. Sometimes this has been supplemented by a formal succinct supervised written component where the student then answers questions directly related to their project.*³¹⁴

A number of submitters pointed out that the ‘hard’ sciences have their own language.³¹⁵ One pointed out that in these subjects:

*Communication is necessary, but with just enough verbosity to supplement a language of mathematical symbols.*³¹⁶

A parent commented that:

Although my letters are about my sons and to some extent about boys in general, the main issue is about assessing each subject within its own right.

³¹⁰ QSA, 10 July 2013. Response to committee, p2

³¹¹ Submission 255, Australian Family Association, p4

³¹² Hansard transcript, 20 March 2013, Mr David Madden, p14

³¹³ Hansard transcript, QSA, 7 March 2013

³¹⁴ Submission 69, Honorary Professor Peter Galbraith, p2

³¹⁵ For example, submissions 222, 264

³¹⁶ Submission 165, Mr Ray Minns

*Literacy based assessment favours students with high literacy skills and disadvantages students with lower literacy skills, whether they be male or female. You don't assess mathematical skills in English so don't assess english skills in maths etc. Yes communication is important but you can have a wonderful speaker who essentially tells you nothing or a man of few words who teaches you so much.*³¹⁷

This issue was of particular interest to committee members. The need to ensure the education system does not disadvantage people who may already be at some disadvantage in our community, such as people with English as a second language and people with lower socio-economic status, is critical. Education is the most primary means of addressing social disadvantage; and the contribution subsequently made by many people who have come from positions of disadvantage bring significant benefit to the community at large.

Other senior QSA subjects appear to offer students more flexible means of presenting their reports. Even in senior English, the extended response tasks do not have to be presented in written form – the syllabus specifies they may be presented in a variety of modes including written, spoken or multi-modal forms.³¹⁸ Modern history also provides for multi-modal presentations. Geography requires a written report, but the syllabus provides more detail as to content than does the physics or chemistry syllabus.³¹⁹

9.1.4 Cheating and unfair advantage

Along with numerical marking, an issue raised most frequently in submissions including from some of those who generally support school-based and standards-based assessment, was that because extended assessment tasks are primarily completed outside the classroom, there is significant potential for cheating, or at the very least to receive substantial amounts of assistance from others such as tutors or parents. There is seen to be a great potential for an unfair advantage to those students, or schools, with greater resources.

The authorship of extended assessment tasks was questioned by a senior physics teacher, who is also a parent, who noted that “[i]f an assessment item is to allow valid and reliable judgements it has to be the student’s own work, obviously. This cannot be guaranteed in the case of assignments, Extended Experimental Investigations (EEIs) or Extended Research Tasks (ERTs) ...”³²⁰

Other teachers, however, saw that developing assessment tasks, and undertaking assessment, was fundamentally exercising their professional skills and indicated that they use their professional judgement in comparing results from different assessment tasks (eg supervised tests and extended inquiry tasks) and close knowledge of their students’ capacity, to determine whether the work is the student’s own. Where there was doubt, these teachers indicated that they seek to verify the work through means such as calling parents or setting additional supervised assessments (tests).

Many submissions highlighted to the committee a belief that plagiarism or cheating is common in the completion of senior assignments. For example, Mr David Best, a mathematics, biology and science teacher, questioned “... who actually does the

³¹⁷ Submission 21, Name suppressed

³¹⁸ QSA, 2010. English syllabus

³¹⁹ QSA, 2007. Geography syllabus, Modern History syllabus

³²⁰ Name suppressed, Submission 230, p1

*assignments. Is it the student, the parent, a tutor, or even an internet based assignment writing service? In contrast, tests and exams leave no doubt who is being assessed.”*³²¹

Mr Andrew Jackson, a former secondary school teacher, also considers that assignment assessments are prone to plagiarism. He recalls a “... Year 8 Student who was near illiterate submitting a near perfect assignment on the Queensland Sugar Industry. Whilst this plagiarism was possible to detect others will avoid detection. Cheating with assignments is now rampant.”³²²

Mr Shaun Fardy, a mathematics teacher for 35 years in Queensland, NSW and Victoria, believes there is “... a lot of cheating in assignments, they must surely be abandoned.”³²³

The role of parents and tutors in completing students’ assignment is considered by Mr Edmond O’Donovan, a parent, to be corrupting the system:

*Apart from assignments grinding any joy out of students, they are open to severe abuse. The issue of cheating is generally ignored though it is very common. I am aware of instances where parents have completed assignments with no input whatsoever from the student. The wider issue of parental or "tutor" assistance is much more complicated but it corrupts the system very badly. Any parent who does not assist their child with an assignment may well be consigning them to the bottom of the class.*³²⁴

The limitations on teachers’ ability to address cheating in assignments was identified by a teacher of senior mathematics, who is also a panellist and assistant head of department:

*Cheating is rampant. I have investigated and proved many cases of students cheating on assignments over the years. Proving that cheating has occurred, however, is incredibly time consuming and given we can only target the most obvious cases (so as not to become embroiled in protracted wars with litigious parents for example) we often grudgingly turn a blind eye. The suggestions of using logbooks or continually monitoring the progress of student work etc. is laughably impractical with large and multiple classes.*³²⁵

A mathematics teacher and administrator with over 35 years’ experience provides a reason why students may cheat on assignments:

Some students at our school have times when they are working on up to seven assignments at the one time. This opens up the possibility of cheating. The QSA is aware of that and indicates that schools should ensure authorship by using strategies such as open ended tasks and check-in periods. Most teachers regard this as time consuming obstructions to getting on with the business of teaching. We know that tutors are often hired to complete assignments or that electronic work is distributed to others and altered slightly in order to pass scrutiny. My school utilises an in-class post- test so that some clarity is available about a

³²¹ Mr David Best, Submission 93, p1

³²² Mr Andrew Jackson, Submission 78, p1

³²³ Mr Shaun Fardy, Submission 83, p1

³²⁴ Mr Edmond O’Donovan, Submission 181, p1

³²⁵ Name suppressed, Submission 8, p3

*student's involvement in the production of their own assignment. Parents, determined to do the best for their children, will do the assignments for them.*³²⁶

The committee understands from private discussions that concerns about authenticity of student work completed without supervision, when it is used as part of the assessment of overall achievement, also exist in other jurisdictions. The Victorian and New South Wales assessment systems address this concern through limiting the extent to which these tasks contribute to the student's overall assessment, and requiring extended assessment tasks to be completed largely in the classroom, under supervision. The Victorian Assessment Handbook for VCE Physics explicitly addresses the question of authenticity and additional support given to students:

Authentication

Teachers should have in place strategies for ensuring that work submitted for assessment is the student's own. Where aspects of School-assessed Coursework tasks are completed outside class time teachers must monitor and record each student's progress through to completion. This requires regular sightings of the work by the teacher and the keeping of records.

The teacher may consider it appropriate to ask the student to demonstrate his/her understanding of the task at the time of submission of the work. If any part of the work cannot be authenticated, then the matter should be dealt with as a breach of rules.

To reduce the possibility of authentication problems arising, or being difficult to resolve, the following strategies are useful:

- Ensure that a significant amount of classroom time is spent on the task so that the teacher is familiar with each student's work and can regularly monitor and discuss aspects of the work with the student.*
- Ensure that students document the specific development stages of work, starting with an early part of the task such as topic choice, list of resources and/or preliminary research.*
- Filing of copies of each student's work at given stages in its development.*
- Regular rotation of topics from year to year to ensure that students are unable to use student work from the previous year.*
- Where there is more than one class of a particular study in the school, the VCAA expects the school to apply internal moderation/cross-marking procedures to ensure consistency of assessment between teachers. Teachers are advised to apply the same approach to authentication and record-keeping, as cross-marking sometimes reveals possible breaches of authentication. Early liaison on topics, and sharing of draft student work between teachers, enables earlier identification of possible authentication problems and the implementation of appropriate action.*
- Encourage students to acknowledge tutors, if they have them, and to discuss and show the work done with tutors. Ideally, liaison between the class*

³²⁶ Mr Christopher Blood, Submission 42, p2

*teacher and the tutor can provide the maximum benefit for the student and ensure that the tutor is aware of the authentication requirements. Similar advice applies if students receive regular help from a family member.*³²⁷

The committee understands that similar approaches are used in Queensland senior classes. However the level of detail provided in the Victorian syllabus material is greater.

Stanley (2012) points out that there is no straightforward answer as to whether work completed outside the classroom was done with a lot of help or is a reliable indicator of what the student knows and can do.³²⁸

Intuitively, one would expect that as classroom teachers are making professional assessments about students every day, on many occasions, and through a range of activities, their assessments of repeated demonstration of achievement over time would be more valid and reliable than a test administered externally on only one occasion.

Some submitters to this inquiry suggested that the extent to which the extended assessment task contributes to the overall assessment for the subject should be limited³²⁹, or that it should not count towards the student's overall assessment standard at all. In the context of a holistic approach to assessment, where all of a student's work over the course of study is considered, this would be difficult to do. However if tasks were numerically weighted, it would be quite possible to limit the contribution to a maximum proportion of the overall mark. This would have the advantage of supporting students, and teachers, to appropriately apportion their time to these tasks. (See also Chapter 11).

9.1.5 Workloads

The key drawback of the use of numerous school and teacher-designed assessment tools is workload, for both teachers, in terms of developing and then assessing the tasks, and students, in terms of the time taken to complete the task to assessed at a high standard, as specified in the syllabus.

Mr Ross Fanning, a teacher for over three decades, describes the workload of physics extended assessment tasks as follows:

*... the syllabus dictates that we have alternative assessment pieces called ERTs & EEIs which stand for Extended Response Task & Extended Experimental Investigation respectively. Four of these must be set over the 2 senior years, their drafts marked and obviously the final submissions marked. The last of these that I set took days to design (content & criteria sheet), the draft commenting took 1½ weeks of most of MY free time & then each of the final copies took ~ 1¼ hours. WITH OVER 50 STUDENTS TO MARK THIS TOOK NEARLY 3 WEEKS!! (I have four other subjects that have to be addressed professionally during this time also!). Let's not forget that the students (OR THEIR TUTORS?!) are also putting in excessive amounts of time to complete these tasks.*³³⁰

³²⁷ VCAA, 2013. Physics Handbook, pp6-7

³²⁸ Stanley, 2012, p15

³²⁹ For example, Submission 43, Mr Steve Ryan

³³⁰ Mr Ross Fanning, Submission 274, p1

A mathematics and physics teacher is concerned about the impact of EEIs on high performing students and on their interest in the sciences. With regard to a specific, high achieving student, Ms Bronwyn Miller notes that “[h]is passion has died because of the workload in his science subjects and his need for perfection. This student’s EEI would make most university students work look inadequate.”³³¹

A current student of mathematics B, who is in Year 11, considers that assignments are time consuming and place increased stress on students:

*Assignment based assessment places constant stress on me and my friends and I believe the assignments get worse in year 12. I am often doing four assignments at any one time. The assignments are so time consuming, I often don’t have time to do my every day homework which I need to do to pass my exams. Assignments use up too much class and homework time.*³³²

A student who completed mathematics B, chemistry and physics in 2012 observed that “... the last 3 weeks of term are the hardest because you have everything due in the same week and you have to get 6 pieces of assessment to do at once in the 2 weeks before.”³³³

Recent student Ms Georgie Richards advised the committee that:

*I found the EEIs were an opportunity for those students who may not have had an automatic grasp of the subject to take the information, go away and study it, to research it, to find out how they could do it and then put a lot of hard work and effort in there and they could actually use that to raise their grades. Those students who were lucky enough to be able to grasp it fairly easily, a lot of them figured that EEIs -I’ll do the basic’ and left it. They were not interested in extending it. So in a way I found that EEIs allow students to raise their marks if they put the effort in. But it is a massive amount of effort that they need to put in to raise those marks. EEIs I found were the most challenging piece of assessment because of the sheer amount of time that they consumed.*³³⁴

A similar issue was identified by a senior chemistry teacher, who is also a parent:

*Perhaps more important, is the damaging effect this assessment is having on the students. They have too many long written assignments, are staying up till very late and have no time for regular revision. My biggest concern is for students who study more than one science or maths subject. My own daughter and second son have experienced extremely levels of stress related to completing EEI’s, ERT’s and Maths assignments. The joy my students used to show during experimental work has been replaced by anxiety and concerns about time constraints and difficulties with concepts not formally taught.*³³⁵

Another teacher and panel chair, Mr Paul Sullivan, reported that:

in my own school there have been instances where highly motivated students have expanded their EEIs well beyond task and syllabus requirements.... (this did not) provide the students any advantage over their peers because the piece of

³³¹ Ms Bronwyn Miller, Submission 101, p1

³³² Mr Mitchell Comben, Submission 150, p1

³³³ Ms Elizabeth Henley, Submission 24, pp1-2

³³⁴ Hansard, 1 October 2013, Ms Richards, p8

³³⁵ Name suppressed, Submission 204, p1

work was graded according to the same criteria and standards present in the syllabus.

The same submission also noted that “some schools were placing demands on their students that were outside the requirements of the syllabus. This I see as a school management issue rather than a syllabus failure.”³³⁶

A current Year 12 student considers that EEs are inequitable and ERTs are too specific:

*The EE assessment method is highly inequitable, favouring students who are financially wealthy and/or have access to resources ... Although ERTs provide students with the opportunity to gain a detailed knowledge about a specific scientific concept, this specialised knowledge is soon lost. For a Year 11 ERT late last year, I evaluated whether cellulose could replace Kevlar in bulletproof vests. I achieved very highly in the ERT, but now cannot remember any of my analysis in the report. Termly, unit-based external exams would assess general knowledge that would be remembered for a longer period of time and which could be applied to a far broader range of situations.*³³⁷

This student recommends that school-based exams, EEs and ERTs be replaced with a “... fair and equitable system of external exams at the end of each term.” However, the student does not support school-based assessment being replaced with an exam that is worth 100% of the overall assessment.³³⁸

Panel chair and teacher Mr David Madden advised the committee that:

*Another key thing for this inquiry is that the task is restricted in a number of ways. Firstly, there is a time limit. You will see that it is about a month that the students have to work on this. There is a word limit—in this case about 1,000 words—for the discussion aspects of it. They also work in groups. Generally my groups are three or four students which means we have about six or seven experiments going on in the class. That helps to restrict the amount of equipment that the school needs and the load on me trying to understand all these different experiments. It is not open slather. The students cannot just do anything. There are some quite important parameters put around it.*³³⁹

Word limits specified in the syllabus documents for extended assessment tasks have reportedly recently been reduced from around 6,000 words to 1,000 – 1,500 words. However as detailed above, it is reported that students are still completing lengthy assignments, and claimed by some that it is not possible to cover the ground required to achieve a strong grade, without considerably exceeding the word limit.

Ms Fiona Hu, a recent graduate of a Queensland school, considers the word limits imposed for EEs was achievable:

... however I found that often in the Discussion aspect of the EE, it was always a struggle to remain within the word limit. I know that many of my friends who were high achievers found it hard to stay within the limit, as did I myself, as

³³⁶ Submission 226, Paul Sullivan, p1

³³⁷ Name suppressed, Submission 87, pp1-2

³³⁸ Name suppressed, Submission 87, pp2-3

³³⁹ Hansard, 20 March 2013, Mr Madden, p11

*extra information that had been researched and wanting to be included in the discussion often was taken out due to the word limit.*³⁴⁰

A student who studied mathematics B, chemistry and physics found it almost impossible to keep within the word limit for chemistry assignments:

*We found that for Chemistry assignments, the word count was almost impossible to keep under; some teachers marked harshly on assignments that were over the word limit, whereas some teachers were more flexible. If there is a small word count such as 1500 words, it should be clearly stated where these words would be placed. (I.e. strict guidelines)*³⁴¹

A teacher with approximately 40 years' experience, who is also a head of mathematics, considers it is difficult for students to address EEI criteria within the word limit:

*Although the QSA argues there is a word limit for EEIs etc. most staff say that it is not possible for 16/17 yr old students to adequately address the criteria within these limits. Hence the documents become extremely large, taking an inordinate amount of time for students to do and very importantly for staff to correct. One consequence of this in our school, apart from it turning students off the subject, is that the staff members with young families are finding the work load prohibitive. These very gifted teachers are opting not to teach years 11 and 12.*³⁴²

Ms Anja Van Hooydonk, a district review panel chair for mathematics B, a school mathematics coordinator and the President of the Cairns branch of the Queensland Association of Mathematics Teachers, told the committee that:

*Even though we set a word limit on the assessment piece, it is often problematic for students to satisfy all of the "A level" criteria within the given word limit. It is very difficult to write the background to your research topic and to do in-depth analysis within a short word limit.*³⁴³

A key issue seems to be that although the QSA suggests maximum word limits, schools are not implementing them:

*The QSA's assessment policy for Mathematics, Chemistry and Physics has resulted in the overuse of long written assessment instead of short numerical problems using mathematics. In some schools, EEIs and other assignments are grossly overused; the write-ups often exceed 5000 or even 10000 words, turning these subjects into de facto English classes. Any motivational experience of doing some cool Physics or Chemistry in the EEI is destroyed by the long write-up. This is a major disincentive for many students who are genuinely talented in these subjects.*³⁴⁴

³⁴⁰ Ms Fiona Hu, Submission 145, p1

³⁴¹ Name suppressed, Submission 23, p1

³⁴² Name suppressed, Submission 187, p1

³⁴³ Ms Anja Van Hooydonk, Submission 85, p1

³⁴⁴ Submission 98, Professor Peter Ridd

It could also be seen as poor assessment practice not to mark down students who do more than a specified word limit. The QTU reminds us that at university or at work, “*brevity and conciseness in communication is an authentic skill*”.³⁴⁵

A group of academics advised the committee:

*... perhaps QSA needs to provide clearer advice on the length and nature of written work such that excessively long assessments are not required of people in physics, chemistry and mathematics. We also suggested that perhaps teachers should be given professional development on how to develop questions that target higher order understanding in more brief written work. Perhaps the training of teachers needs to be addressed in this area.*³⁴⁶

However, the QTU suggests that the problem could lie in the standards themselves, stating that the use of a qualitative approach to assessment favours extended responses to questions, and that the current standards as written do not provide for actually penalising a student for exceeding the word limits. The QTU suggests that standards should contain descriptors that give direction to teachers and students to meet the prescribed word limits.³⁴⁷ It was also suggested that the syllabus could even allow for students to be marked down for exceeding word limits.

In Victoria, where school-based assessment is worth 40% of a student’s total mark, the Study Design document for HSC chemistry says:

Assessment tasks must be a part of the regular teaching and learning program and must not unduly add to the workload associated with that program. They must be completed mainly in class and within a limited timeframe. Where optional assessment tasks are used, teachers must ensure that they are comparable in scope and demand. Teachers should select a variety of assessment tasks for their program to reflect the key knowledge and key skills being assessed and to provide for different learning styles.

School-assessed Coursework in Chemistry includes assessment of laboratory/practical work. As a guide, between 10 and 15 hours of class time should be devoted to student laboratory/practical work. Students should maintain records of their work.

*The extended experimental investigation could be student designed and/or planned or teacher directed and would require between three and five hours of practical work. Students could work in pairs or small groups but must present the results individually. Students should complete a Risk Assessment and Risk Management as part of this task. Results could be presented in a variety of formats.*³⁴⁸

Additionally, in Victoria the school based components of assessment (including extended inquiry type tasks) are required to be mostly completed in the classroom. While the VCAA does not set word limits it does suggest appropriate timeframes for each component of the assignment process.

³⁴⁵ Submission 26, QTU, p3

³⁴⁶ Hansard, 1 May 2013, Dr Carole Haeusler, p6

³⁴⁷ Submission 26, QTU p3

³⁴⁸ VCE Study Design, Chemistry, Accreditation period 2013 – 2016, pp23 and 27

9.1.6 Mental health

Associated with the workload issue is the claim made in a few submissions (including three from medical professionals) that the stress of continuous high stakes assessments, particularly assignment type assessments, is damaging the mental health of young people. The interim report of the Senate Education, Employment and Workplace Relations References Committee found the same was being reported in respect of the annual NAPLAN tests. In essence, it seems that testing that is seen to be high stakes is negatively affecting children, at all year levels.³⁴⁹

Some submissions raised specific concerns about the continuous approach to high stakes assessment that is part of the senior process, with particular reference to extended assessment tasks in that context.

For example, teacher Mr Leon Perry noted that:

*The removal of external exams was supposed to relieve the stress levels of students, amongst other things. The reality is far different with peak stress periods being spread across two years of Chemistry and Physics education. This is not limited to two subject areas but in concert with assignments across all the Senior subject areas exacerbates the stress levels experienced by students.*³⁵⁰

9.1.7 Common assessment tasks

In the previous chapter (Standards-based assessment) we discussed the difficulty some teachers are having with interpreting and applying the standards to assess students' work. Those teachers are also required to design assessment tasks, and it would seem likely that they would also have some difficulty in that respect (with implications for validity, again).

Several submissions suggested that a number of the identified problems might be addressed by standardising some or all assessment tasks, through establishing a bank of externally set tasks. These could have associated assessment guides, to promote a good understanding of the standards, both improving the reliability and validity of assessments; and reducing the workload associated with developing and assessing tasks. Dr Lawrie and Dr Raynor, academics in chemistry and physics at the University of Queensland, identify that many of the concerns being raised seem to be based on need for a common understanding of the expectations in applying benchmarks.³⁵¹ They suggest creating the infrastructure to develop the required common understanding, including a formal 'hub' for community of practice. Common assessment tasks or at the very least, common frameworks for setting assessment tasks, would also address this goal. This would support the many non-specialist teachers teaching these subjects, and lead to better quality learning for students. The QTU indicated support for this approach.³⁵²

Committee comment:

That different students experience extended assessment tasks differently is not at all surprising, given different learning styles and preferences. This strengthens the argument

³⁴⁹ The Senate Education, Employment and Workplace Relations References Committee, 2013. Effectiveness of the National Assessment Program – Literacy and Numeracy, interim report, p9

³⁵⁰ Submission 68, Mr Leon Perry, p3

³⁵¹ Submission 250, Dr Gwen Lawrie and Dr Anton Rayner, p3

³⁵² Submission 26, QTU

that there should be a range of assessment tasks so that all students have the best opportunity to demonstrate their achievement.

Only one extended inquiry task is mandated in each of these subjects over the Year 12 program of study. It seems surprising that what should seemingly be such a small part of a student's overall assessment workload, even if they are undertaking the apparently anecdotal "suicide six" subjects of English, Maths B, Maths C, Physics, Chemistry and Biology³⁵³, should be attracting so much attention. The answer seems to lie in how the requirement is implemented at the school level, which has implications for how the syllabus is detailed and communicated: and perhaps in the format in which these assessment tasks must be presented (written) as distinct from formats (for example, multi-modal) allowed in some other subjects.

It might be beneficial for the syllabus to specify time limits rather than word limits. While that might mean that students are less able to take away a task to perfect it, it does reduce the pressure for both students and teachers, and the risk that work that contributes to overall assessment is inauthentic. This is seen as a reasonable balance.

If there is bias in either direction related to the use of written tasks as one component of a student's assessment (noting that the majority of assessment tasks are short answer tests or exams), then that strengthens the case for having a range of assessment types available so that all students have the best chance to demonstrate their achievements.

The committee acknowledges the principle of assessment for learning but also sees that these tasks can still be used as valuable teaching tools without them being such high stakes assessment tools.

The committee accepts that:

- inquiry-based assessment tasks are fundamental to the nature of science and mathematics, and encourage a depth of understanding of these subjects – essential to encouraging innovation, and critical to individual, as well as social and economic, growth, and
- that there are reasonable concerns about the extent to which there is confidence that students are on a level playing field when it comes to support for completing those tasks, and the impact for higher levels of support to result in a higher overall assessment of achievement in that subject, inaccurately.

Recommendation 7:

The committee recommends that the syllabus prescribe that inquiry-based assessment tasks such as extended modelling, extended experimental investigations and extended research tasks, be completed in class time under teacher supervision, and that it specify a maximum number of hours that can be spent on these tasks.

Recommendation 8:

That inquiry-based assessment tasks be mandated at no more than one in each of year 11 and 12 (with schools free to use a maximum of two)

³⁵³ Hansard, Mr Brad Ahern, 22 May 2013, p8

Recommendation 9:

That inquiry-based assessment tasks contribute to a defined proportion of a student's overall mark for that subject (a minimum of 12.5% and a maximum of 25%)

Recommendation 10:

That inquiry-based assessment tasks can be presented in a range of formats, including oral presentations, visual presentations as well as in a written report format.

Recommendation 11:

The committee recommends that a 'catalogue' of common inquiry-based assessment tasks, developed by trained specialist teachers and with associated task-specific assessment guides be developed to support teachers. The national curriculum may provide an opportunity for sharing of resources and experiences on a national scale, with support from industry and academia.

Recommendation 12:

That students be routinely questioned on aspects of their inquiry-based assessment task as part of the assessment process.

10 The marking regime

Any assessment task should clearly link to the assessment criteria, pre-specifying what answers (in a test) or features (in an assignment) demonstrate each standard. A criteria sheet for each assessment task is developed for this purpose. At the end of the course, a teacher reviews a student's results for all of the individual pieces of work, and relate those back to the standards relevant to each criteria (as outlined in the syllabus) and make a professional judgement about the student's overall assessment.

The QSA briefed the committee about how the assessment process works, on 20 March 2013. Three teachers and review panel chairs, Ms Jackie Klowss, Mr Bevan Penrose and Mr David Madden provided a thorough explanation of how the system is intended to operate.³⁵⁴

10.1.1 Criteria sheets

Teachers develop criteria sheets based on the standards specified in the syllabus for each criteria, in respect of each assessment task. An example of a criteria sheet is provided at page 28. Summaries of the achievement levels demonstrated on each assessment task, are subsequently recorded on an overall student profile sheet which relates back to the three criteria for the subject. This ensures the teacher and student can see to what extent the student met each of the criteria, based on a holistic and qualitative view of their assessment tasks over the study program.

A number of teachers report that criteria sheets are unwieldy and complicated, and confusion about their use seems evident.³⁵⁵ For example, a mathematics and science teacher told the committee that “[t]he criteria paragraphs, QSA standards, are the most confusing criteria I have ever seen. They are subjective and unhelpful.”³⁵⁶

Another teacher does not consider the introduction of these criteria as a positive step in mathematics education:

*I have been at the coalface of Ed Qld for 40 continuous years – I teach Mathematics to all year levels. As someone who has observed many changes across Education over that period can I state that the criteria based assessment for Mathematics is the most confusing manner in which to report back to students and parents and would be among the worst of educational changes observed.*³⁵⁷

Mr Tony Chamberlain believes “[a] parent would find assessment criteria too complex to interpret and understand.”³⁵⁸

A mathematics teacher for 36 years, and a head of department Mr Ray Minns and his students find criteria based assessment confusing:

The current system of criteria based assessment is confusing to me and to my students. I have tried numerous times to explain it to parents with very few

³⁵⁴ Hansard, 20 March 2013

³⁵⁵ See for example, Submissions 43, 174, 215

³⁵⁶ Name suppressed, Submission 14, p2

³⁵⁷ Submission 2, Mr Barry Flowers, p1

³⁵⁸ Submission 75, Mr Tony Chamberlain, p1

*comprehending it. All parents just want to know is whether their child is passing Mathematics and has an A, B or C. Some ask for a percentage, which, of course, I can't give them. I can at least do this for our Year 7 to 10 students and parents since I refuse to carry this same Senior system of criteria based assessment down into the Junior High School.*³⁵⁹

The committee heard from a student who completed mathematics B, chemistry and physics in 2012. She provided her experience of using the criteria:

*My teachers in all three of these subjects strove to make the class understand the marking criteria, but the truth of it is, we just can't understand that wording. It's horrendous. Eventually I worked it out, but by harassing my modern history teacher with questions about it, and then I was able to understand the criteria in other subjects as well. Especially in maths based subjects like physics, maths and chemistry the criteria are especially difficult. I think one of the main complaints about it is the packing together of so much information in one sentence, I think that's what confused us mainly.*³⁶⁰

As pointed out by ACER, the more complex the assessment task the more complex the criteria sheet (also known as an assessment rubric) must be;³⁶¹ and presumably, the more professional judgement is required. And so, it is vital that the criteria sheet is as clear and unambiguous as is possible, to ensure the validity of that professional judgement. How clear it can be when the standards as specified in the syllabus are themselves not clear, is questioned (see Chapter 8), let alone given the possible options for assigning standards as outlined below.

A number of submissions gave examples about the difficulty of assessing the standards achieved against the criteria for any given assessment task. The following example of the possibilities are explained by the author of submission 64:

Knowledge and conceptual understanding			Investigative Processes			Evaluating and Concluding		
C standard questions	B standard questions	A standard questions	C standard questions	B standard questions	A standard questions	C standard questions	B standard questions	A standard questions
Maximum mark C+	Maximum mark B+	Maximum mark A+	Maximum mark C+	Maximum mark B+	Maximum mark A+	Maximum mark C+	Maximum mark B+	Maximum mark A+

Table 6: Criteria based marking in exams (even for short answers).

E.g. the top student with everything correct would end up with a score consisting of 9 "symbols" i.e. C+ B+ A+ C+ B+ A+ C+ B+ A+

All possible results:

C standard questions = 9 possibilities, C+ C C- D+ D D- E+ E E-

³⁵⁹ Submission 165, Mr Ray Minns, p1

³⁶⁰ Submission 24, Ms Elizabeth Henley, p1

³⁶¹ Submission 58, ACER p3

B standard questions = 6 possibilities, B+ B B- C D E

A standard questions = 7 possibilities, A+ A A- B C D E

Therefore, for 1 exam, there are $9 \times 6 \times 7$ possibilities for each criterion and $(9 \times 6 \times 7) \times 3$ for all 3 criteria = 1134 possibilities for a student's result.

There used to be 100 possibilities when we used a percentage.³⁶²

Not every assessment task, or every question in a supervised assessment test or exam, will provide opportunities for a student to demonstrate a high level of achievement (say an A or a B standard). Some teachers report difficulty in then determining the student's overall level of achievement for that task.

The author of submission 152 said:

Assessing a single question on a Maths B paper can require as many as 10 sub-criteria to be considered. Even for multi-step questions, it is almost impossible to clearly subdivide a student's response and underlying thinking into so many parts, and then guarantee that another teacher would interpret and classify the response in the same way.³⁶³

This is because there are a number of features specified, for each standard of achievement, in three separate criteria. Again, this issue relates to the fact that there are three criteria, and not just one, because the syllabus aims to teach more than content and procedural knowledge.

It also relates to what appears to be a (fairly logical) difficulty experienced by teachers trying to 'add up' letters, rather than numbers.

Some submissions³⁶⁴ raised concerns with an approach used in some schools, whereby some tasks or questions can only earn a 'C' assessment. A teacher and psychologist who submitted to this inquiry that this was potentially demoralising for students:

...it marks students with very coursegrained [sic] Ds and Cs for perfectly correct answers just because the QSA deems the questions too simple or routine....

....the demoralising effect of using letters to mark down students work when they are getting correct answers appears to be the most disturbing part of this so called system. I fail to see how this can do anything but discourage students. It would be particularly demoralising to students who are just getting things half correct. In the traditional but correct system that the QSA has rejected, their efforts should be given part marks – with numbers – and then added up.³⁶⁵

Professor Ridd described the assessment process undertaken by teachers as follows:

In the Queensland Studies Authority syllabi, every exam question will be given a rating from A to E or some of them might only have a maximum of C. So for some questions you can get full marks but you only get a C. The exam might have 10 questions all with letters and then the teacher must make a holistic

³⁶² Submission 64, Name suppressed

³⁶³ Submission 152, p1

³⁶⁴ For example submission 29, Mr Stephen Kazoullis, submission 255, Australian Family Association

³⁶⁵ Submission 283, Ms Margaret McDonald

judgement, which is just a guess really, as to what the final grade will be. It might be B minus.

*They then have to take the results of maybe the three or four exams and the EEIs and the ERTs and they will have a matrix of letters, which is on the back page of the submission I gave to you, and they make another holistic judgement about what the final mark will be.*³⁶⁶

Noting that the question of how to identify which of the standards a student is demonstrating on a particular question is a matter for an individual school, the QSA advised that:

*When grading tests, teachers are not required to award A to E standards to individual questions. Schools that use some form of labelling do so as they find it assists them in tracking the opportunities that students have had to demonstrate the full range of standards across a two-year assessment program..... Decisions about the methods of grading assessment tasks are school decisions and school decisions only. Whatever method for grading/markings a school chooses to use must be understood by teachers, students, parents and the panel members reviewing student folios.*³⁶⁷

10.1.2 Determining an overall grade

The syllabus for each subject advises teachers about how to determine the overall level of achievement for that subject. A student profile, derived from the criteria sheets for each assessment task that student has completed, will show a final assessment for each of the three criteria, and then a teacher is to determine the final level of achievement as follows:³⁶⁸

VHA	Standard A in any two criteria and no less than a B in the remaining criterion
HA	Standard B in any two criteria and no less than a C in the remaining criterion
SA	Standard C in any two criteria and no less than a D in the remaining criterion
LA	At least Standard D in any two criteria
VLA	Standard E in the three criteria

Table 7: Final level of achievement.

In the State Review Panel reports for 2012, the panel chairs for mathematics B and mathematics C both noted that:

The match between syllabus standards and the evidence in student folios was found to be in significant alignment.

A concern about a small but significant number of level of achievement decisions arose when decisions were not made using on-balance judgments. Where a mechanical or formulaic method was used to determine standards in a

³⁶⁶ Hansard, 6 March 2013, p18

³⁶⁷ QSA, 14 May 2013, Correspondence

³⁶⁸ QSA, Chemistry syllabus, p26

*criterion, there was little alignment to the specific standard descriptors. An on-balance judgment should be used to determine the standard awarded in each criterion. Schools should always match student work to the syllabus standards descriptors, no matter how assessment data is collected. This concern was identified particularly at the interface between Sound Level of Achievement (SA) and Limited Level of Achievement (LA).*³⁶⁹

This advice appears to make it clear that numerical marking is not encouraged for adding up scores on individual assessment tasks to reach a final overall achievement level; whether or not it is used for the individual assessment tasks throughout the course of study. This does not appear to be a clearly understood distinction, by teachers doing assessment or participating on panels.

Using numerical indicators of achievement would seem more logical than attempting to compute with letters, as some teachers are clearly doing. As one (former) teacher and head of school mathematics departments, Mr Paul Bannister advised the committee:

*The interesting procedure of going from a verbal (qualitative) criteria sheet to a quantitative profile sheet (quantitative because teachers have to somehow “average” several assessments into a subject grading on a 15-point scale (A to E with + and -, such as B+ or C-) AND then use this to go to an R6 exit arrangement with 50 points on it and for large subjects proceed to a 200 point scale defies even the smartest thinkers. [That] a measurement becomes less reliable the more you do with it is basic science.*³⁷⁰

ACER, in its submission to this inquiry, advised the committee that:

When it comes to combining evidence across assessment tasks, the simplest, most reliable and fairest method is simply to sum marks across tasks. If an assessment booklet consists of twenty tasks all scored right or wrong, then the best way of combining responses to those tasks is simply to assign a score of 0 for a wrong response and a score of 1 for a right response and to sum over the twenty tasks to obtain overall student scores in the range 0 to 20. If an assessment booklet contains some tasks with a 3-level rubric (eg, by recognising the partially complete solution of a task), then the three levels on those task rubrics are best scored 0, 1 and 2, with scores again being summed across all tasks. If a student performance (eg, in dance) or a product of student work (eg, a research project or piece of artwork) is judged on, say three, separate criteria, each with a rubric that defines five levels of quality, then those levels are best scored 0 to 4 and – if an overall assessment is to be made – summed across the three criteria to obtain student scores in the range 0 to 12.

When task responses/performances are combined in this way, the conclusion reached about a student’s overall level of achievement in the domain being assessed is an ‘on-balance’ conclusion. This is because low performances on some tasks (or criteria) can be compensated for by high performances on others. And when all students attempt the same sets of tasks, their total scores on this set of tasks can be compared directly, without attempting to take into

³⁶⁹ QSA, 2012. State Review Panel Reports, p68; p70

³⁷⁰ Submission 174, Mr Paul Bannister

*account differences in task difficulty. Again, there is good psychometric evidence to support this practice.*³⁷¹

Committee Comment

Numeric marking could be readily used to give weighting to particular questions or tasks, removing the confusion that appears to arise from having B or C level questions, as schools attempt to place questions on a continuum. Tasks or questions that assess limited aspects of the three criteria can be worth fewer marks towards a total, than those which allow a student to demonstrate a depth of understanding and a very high level of achievement against the criteria. This also allows students to focus their efforts to the tasks and questions which will give them the greatest prospects of achieving the best grade possible or, if they are not the highest capacity students, to demonstrate that they have sufficient content knowledge to pass the subject (or not).

There is undoubtedly a high degree of professional judgement required within this regime. The assessments are clearly not 'just a guess', any more than are assessments in other subjects that assess higher order skills, such as English Literature or Ancient History, and where more subjectivity is necessary than for assessing core content knowledge (lower order skills). The fact that these more subjective assessments must be justified by an explicit relationship to the standards for each criteria through the use of criteria sheets ensures this. More detailed standards would decrease the effects of that subjectivity, however, and that is desirable in terms of promoting validity and reliability.

The submissions received by the committee indicate that the methods of grading assessment tasks are not well understood by those who need to understand them. A consistent, simple approach at all schools would help to ensure that they were understood, and enhance confidence in their validity.

The broad range of methods used to reach a decision about what mark a student should be awarded for any given task is confusing, some methods more so than others.

On the face of it, it would be considerably simpler, and perhaps more valid, to sum marks across a series of tasks than it is to add up the number of letters representing different standards of achievement on a series of tasks.

Once again the committee believes that the marking regime should be fit for purpose, and as simple as it can possibly be to achieve its intent. The recommendations in the following section, numerical marking, reflect this.

³⁷¹ Submission 58, ACER

11 Numerical marking

With an external exam, and all the recommendations made to date, the approach to grading, that is, whether numerical marks can be used within that, is a separate issue.

The question of numerical marking is clearly fraught, and has been the cause of considerable distress for some teachers who made submissions to this inquiry. It was overwhelmingly the most frequently and consistently expressed concern. Even individual teachers who generally supported the broad approach to assessment (school-based, standard-based) used for senior mathematics, chemistry and physics, objected to the perceived ‘ban’ on using marks.

Numeric marking does not in itself resolve the difficulty reported by some academics in knowing what a student knows, from their overall assessment for a subject.³⁷² For example, if a SA equates to 60 to 70%, it could still mask the fact that the student did very well on communication, but less well on the knowledge and procedures criteria.

Teacher Mr Mal Hartwig, who from 2000 – 2012 has been the chief examiner in respect of one of the mathematics external exams set by the QSA³⁷³, submitted that:

*[The external exam] allowed me to assess each topic according to the contribution it made to the syllabus – for example, introduction to functions 35 hours, optimisation 25 and so on – and to also include a balance of the attributes of each criterion within each item and then have the makings of a marking scheme. Marking was then relatively easy and the agreement between markers on one-third of cross-marking was 100 per cent last year.*³⁷⁴

ACER supports the use of numerical marking where appropriate, drawing a distinction between numerical marking the various assessment tasks that are completed over the course of study, and the overall assessment of achievement at the end of the course of study.

Students who informed the inquiry were also generally supportive of the concept of numerical marking. Recent student Mr Connor Emmanuel Smith commented:

I found the change to university somewhat confusing, but quite refreshing. In the first week of the study period, we were presented with a breakdown of our total grade for each subject, and the percentage of this that each individual component is worth. I found this reassuring.

*Of even more benefit than this is the numerical assignment of grades within each assessment piece. Even before the date of the exam or quiz, we are told how many marks each question will be worth. This, I find, really allows students to schedule their answer times within an exam, and is of further assistance in knowing how much depth is required for a particular answer to more general questions.*³⁷⁵

Not all universities and all schools within universities use the same approach to assessment. Students who did subsequently experience a numerical marking system at university,

³⁷² See Chapter 8, Standards-based assessment

³⁷³ See Chapter 13, Cost implications

³⁷⁴ Mr Mal Hartwig, Hansard, 21 May 2013

³⁷⁵ Submission 257, Connor Emmanuel Smith

though, tended to report that they found it easier to understand than the system they had experienced at school.

A student who completed Year 12 in 2012 told the committee that he found the transition to university from school confusing, but refreshing:

In the first week of the study period, we were presented with a breakdown of our total grade for each subject, and the percentage of this that each individual component is worth. I found this reassuring.

Of even more benefit than this is the numerical assignment of grades within each assessment piece ... I find that the numerical marking system provides a very transparent and understandable reason for the assignment of the grade I received for that piece. During secondary school, I didn't always understand why I received a particular grade. I found that even the teachers struggled to interpret the wordy criteria, yet alone my fellow students and I.

Beyond the marking system, I believe the type of assessment prescribed in high school failed to prepare me for the assessment employed by university.³⁷⁶

11.1.1 Assessment task level

ACER advised the committee that:

... the approach to recording student performance on an assessment task or activity needs to be appropriate to the task or activity. This issue, I believe, was the precipitate for this inquiry. In Queensland you see a philosophical preference for criteria and standards at the task level. It is our opinion that the marking guides in their current form are an unnecessary extension of the principles of valid and reliable assessment—principles that apply in any system including one that is teacher based. Awarding one of five levels of achievement comes at the end of a course of study when teachers look at results over all assessments over all four semesters and make an on-balance decision about the standard obtained by a particular student. This should be the only place where overarching criteria and standards are applied. The change that is required here is to recognise that it is not appropriate to impose a single approach—the use of the criteria and standards matrix—for recording results on all forms of assessment at the task level. Maybe it could be left to the discretion of teachers as to how to record performance on individual tasks.

The QTU, representing some 44,000 Queensland teachers, submitted that the use of marks can be more appropriate than standards descriptors for assessing some tasks:

Qualitative, criterion –based standards referenced assessment is the preferred method of assessing extended responses to assessment tasks, however it is not as well suited to assessing shorter answer tasks. While the QSA's official response has been that there is nothing stopping teachers using quantitative methods to arrive at a level of achievement in an appropriate task, this position is often contrary to advice received from some district panels, who say that such methods are not supported by the standards stated in the syllabus.

³⁷⁶ Mr Connor Emmanuel Smith, Submission 257, p1

Further complicating this situation is the fact that advice is not consistently given across all district panels.³⁷⁷

Many individual teachers reported receiving the same advice.³⁷⁸

The QSA has emphasised to the committee that “the QSA has not banned the use of marks”.³⁷⁹ A QSA assessment policy document states that:

teacher judgments made using numbers, letters or other symbols must explicitly identify the standards demonstrated and how the qualities in the student responses match the standards described in the syllabus.³⁸⁰

Mrs Walton advised the committee as follows:

Let me be clear: QSA has not banned the use of marks. QSA has not banned the use of marks. In 2010 this was further emphasised in the QSA policy on using standards to make judgements about student achievement. This is on our website. Teachers are required to record their judgements about student achievement and this could be done by using numbers, letters or symbols for that matter. However, these marks can only ever be a guide to how well the standards have been demonstrated in students' work. The crucial activity for teachers is to go beyond these symbols and clearly show how students' work matches the standards in the syllabus. This is the true indicator of achievement. It may appear to be common sense that a student got 85 questions right and 15 wrong on a test, therefore their overall achievement is 85 per cent and they appear to have achieved highly. But what does this number mean? What was the test actually assessing? What standard was expected of the student?³⁸¹

Whether there is a communication problem and QSA officers and panel members are not as clear as their CEO is about the use of numeric marks; or whether as has also been claimed, the QSA is using semantics to miss the point³⁸², there is undoubtedly a widespread perception that the QSA does not support, and does not allow, the use of numerical grading to determine student's achievement in mathematics, chemistry or physics (or any other subject) either at the task level or for determining overall achievement.

Teacher Mr Mal Hartwig suggested that the QSA could provide support to teachers as to how, using marks, one explicitly identifies how the student has met the standards specified in the syllabus.³⁸³

In response to a question from the committee chair about why the QTU views qualitative criterion based standards reference assessment as the preferred method of assessing responses to extended assessment tasks but not for shorter answer tasks, Dr Peter Darben, representing the QTU, replied:

I guess it comes down to the mechanics that you actually use in assessing things. If I had an extended response task and I were to use a quantitative

³⁷⁷ Submission 26, QTU, p2. See also Hansard, 21 May, Dr Peter Darben (QTU), p3

³⁷⁸ List egs. Submissions 68, Mr Leon Perry; Brad Ahern,

³⁷⁹ Hansard, 6 March 2013, p5

³⁸⁰ QSA, April 2010. Policy, Using standards to make judgements about student achievement in Authority and Authority-registered subjects, p3. http://www.qsa.qld.edu.au/downloads/approach/qa_policy_standards.pdf

³⁸¹ Hansard, 7 March 2013, Mrs Walton, p5

³⁸² Ridd – Plato website and submission 98

³⁸³ Hansard, 22 May 2013, Mr Mel Hartwig, p15

method for assessing that I would in my head be essentially following a qualitative process. I would be looking at the students' work and saying, 'They did pretty well there; they get nine out of 10.' I would still be making a qualitative judgement.

The difference in the new standards is that they specifically mention qualities of the student work that you need to find. You need to find complexity in the student's work for them to get an A level of achievement in many of the standards. You need to be able to see the student explaining things. That actually is a lot easier to talk to students and parents about. When they come up to you and say, 'Why didn't I get an A?', under a quantitative method you just say, 'You did not say enough stuff that I could add together.' As opposed to under a standards reference I can say, 'You explained things, but you didn't actually make those complex links which would push you up into the A. So the next time you do it that is what you want to do.' It is all about giving much richer feedback to the students and guidance in how they can get higher levels.

When you come to a shorter response task, such as what we might think of as an exam—they are now called written tasks—they are about accumulating knowledge. Some sort of quantitative method of bringing that information together certainly makes life a lot easier. Even if you do use standards and each question has standards associated with it, at the end of the day you still have to use—even if it is in your head—at least a semi-quantitative way of accruing all those marks together to make it fair.³⁸⁴

And retired teacher Mr Leon Perry advised:

In fact, I think what is involved here is Occam's razor principle. If you have two different ways of arriving at the same sort of result—in other words, the ranking of students according to ability and so forth and performance—the simpler way is the preferred method of use, and marking is a lot simpler. It is not any less—I am searching for a word here—effective than using the letters. I think the use of letters is rather coarse grained. They are more subjective than using marks. It is one of the principles of science that if there are two competing theories or ways of doing things the simpler one is the preferred method.³⁸⁵

Importantly, there may be a direct causal relationship between the perceived need to use descriptive standards rather than numeric marking to assess all assessment tasks, and the use of extended assessment tasks to an extent that is more than the mandated number. The QIU points out that:

Creating and marking short answer assessment items using the current standards is a difficult and time consuming process, with the result that many schools have dropped these items from their assessment package in favour of items requiring an extended response. Such items allow a deeper demonstration of knowledge in a particular subject however they are by their nature more narrow than a short answer item and may not be the most suitable

³⁸⁴ Hansard, 21 May 2013, Dr Peter Darben (QIU), p3

³⁸⁵ Hansard, 21 May 2013, Mr Leon Perry, p8

*assessment type for a particular topic. As a consequence, the items themselves become shorter and individual questions therefore become more “high stakes” for the students.*³⁸⁶

Mr Peter Thomas, a retired teacher strongly supportive of the use of descriptive standards for the humanities, where an element of value judgement is required, offers a simple explanation about how marks can be used within a standards-based system:

*The placement of students in bands of achievement resulting from such marks could be readily agreed upon, I believe, without returning to external examinations. In any case, it would present no greater difficulties than those currently experienced in implementing the criteria-based method.*³⁸⁷

This is in fact the approach used in Victoria at the task level (and for overall assessment). The following example from the assessment handbook for senior (VCE) chemistry relating to an assessment task³⁸⁸, illustrates this:

Unit 3 Task 1 – Extended experimental investigation

An extended experimental investigation that can be drawn from either Area of Study 1 or Area of Study 2.

MARK RANGE	DESCRIPTOR: typical performance in each range
41–50 marks	Demonstrates comprehensive knowledge and understanding of the principles and applications of techniques of analysis, or the role of functional groups and types of reactions in organic reaction pathways. Accurately applies ideas and concepts to familiar and new contexts. Plans and/or designs and conducts a comprehensive investigation. Works independently and collaboratively and accurately and appropriately records insightful and detailed quantitative and/or qualitative observations with correct units, including the use of tables. Manipulates data accurately and in detail. Accurately identifies and addresses most possible sources of uncertainty in the investigation. Draws clear and concise conclusions consistent with the question under investigation and the information collected. Evaluates the procedure effectively and discusses the reliability of data accurately and in detail. Comprehensively and accurately interprets, explains and communicates chemical information using scientific language and conventions. Demonstrates comprehensive knowledge and understanding of risk assessment, risk management, and the ethics of scientific research. Accurately explains the appropriateness of the safe and responsible work practices used in the investigation. Communicates findings from the investigation accurately, concisely and effectively.
31–40 marks	Demonstrates detailed knowledge and understanding of the principles and applications of techniques of analysis, or the role of functional groups and types of reactions in organic reaction pathways. Accurately applies most ideas and concepts to familiar and new contexts. Plans and/or designs and conducts a detailed investigation. Works independently and collaboratively and accurately and clearly records detailed quantitative and/or qualitative observations with correct units, including the use of tables. Manipulates most data accurately and clearly. Accurately identifies and addresses many possible sources of uncertainty in the investigation. Draws clear conclusions consistent with the question under investigation and the information collected. Evaluates the procedure and discusses the reliability of data accurately. Accurately interprets, explains and communicates detailed chemical information using scientific language and conventions. Demonstrates detailed knowledge and understanding of risk assessment, risk management, and the ethics of scientific research. Relates the safe and responsible work practices used in the investigation appropriately. Communicates findings from the investigation accurately and effectively.
21–30 marks	Demonstrates sound knowledge and understanding of most of the principles and applications of techniques of analysis, or the role of functional groups and types of reactions in organic reaction pathways. Accurately applies many ideas and concepts to familiar and new contexts. Contributes to the planning and/or designing and conducting of a detailed investigation. Works collaboratively and accurately records relevant quantitative and/or qualitative observations with correct units, including the use of tables. Manipulates most data accurately. Identifies many and addresses some possible sources of uncertainty in the investigation. Draws conclusions mostly consistent with the question under investigation and the information collected. Evaluates some of the procedure and discusses some aspects of the reliability of data. Accurately uses scientific language and conventions. Demonstrates sound knowledge and understanding of risk assessment, risk

³⁸⁶ Submission 26, QTU, p3

³⁸⁷ Submission 34, Mr Peter Thomas, p3

³⁸⁸ VCAA, 2012. VCE Chemistry assessment handbook 2013-2016, p11.
www.vcaa.vic.edu.au/Pages/vce/studies/chemistry/chemindex.aspx

	management and the ethics of scientific research. Links the use of appropriate safe and responsible work practices to the investigation undertaken. Communicates most findings from the investigation accurately.
11–20 marks	Demonstrates some knowledge and understanding of the principles and applications of techniques of analysis, or the role of functional groups and/or types of reactions in organic reaction pathways. Accurately applies some ideas and concepts to familiar contexts. Contributes to the investigation and works collaboratively. Records quantitative and/or qualitative observations with some correct units, including some use of tables. Manipulates some data accurately. Identifies and addresses some possible sources of uncertainty in the investigation. Draws some conclusions consistent with the question under investigation and/or the information collected. Evaluates some of the procedure and/or discusses some aspects of the reliability of data. Displays some accurate use of scientific language and conventions and some knowledge and understanding of risk assessment, risk management and the ethics of scientific research. Lists some of the appropriate safe and responsible work practices used in the investigation. Communicates some of the findings from the investigation accurately.
1–10 marks	Demonstrates very limited knowledge or understanding of the principles and applications of techniques of analysis, or the role of functional groups and/or types of reactions in organic pathway reactions. Applies few ideas or concepts accurately to familiar contexts. Contributes to the investigation and records some quantitative and/or qualitative observations. Manipulates very little data with accuracy. Very limited identification of possible sources of uncertainty in the investigation. Draws very few conclusions consistent with the question under investigation and the information collected. Provides a very limited evaluation of the procedure and/or discussion of the reliability of data. Displays limited use of scientific language and conventions and limited knowledge or understanding of risk assessment, risk management and ethics of scientific research. Provides very limited reference to appropriate safe and responsible practices used in the investigation. Very limited findings from the investigation are communicated.

Table 8: Example from the assessment handbook for senior (VCE) chemistry relating to an assessment task.

(Note also that this detailed task assessment sheet is contained in the syllabus documentation).

Numeric marking and standards-based assessment are not mutually exclusive and indeed the NSW and Victorian systems make that clear.

The author of submission 121 explains that:

*In other states external exam results are recorded as marks which are matched to the criteria standards identifying the points at which student work becomes representative of the different levels (grades) in the standards. It is just as much a standards-based approach as that used in Queensland with the advantage that a common reference exam in each subject ensures that the same standard is being applied across the state.*³⁸⁹

Numeric marking, which would support a simple adding up of what is right and what is wrong – the absolutes – would seem to be most appropriate for assessing the criteria around knowledge and conceptual understanding (physics, chemistry) and knowledge and procedures (mathematics). And standards of achievement in respect of these criteria would also seem to be the most conducive to being tested in an exam situation. While teachers may in fact be allowed at the present time to use numbers to grade individual assessment items (though not to add them up to obtain an overall final subject achievement level) there does not appear to be guidance from the QSA on how to specifically refer numerical assessments back to the standards specified for each criteria.

It is notable that the Victorian assessment does require marks to be allocated for each assessment task. While it uses different terminology, it appears to be essentially a criteria – standards matrix that is used for each of the mandated assessment tasks, which specifying

³⁸⁹ Submission 121, name suppressed, p2

the numeric mark range to be applied where the specified standards are met. Victoria then adds the marks for each task to achieve an overall achievement standard for the subject.

11.1.2 Overall assessment

It is acknowledged that the OP system is designed to measure a student's performance in comparison with other students (ranking) while senior assessment is designed to measure students achievement against the specified outcomes for the subject. However on the face of it, there is a contradiction inherent in using a completely standards-based assessment system that is then fed into the OP system to be manipulated into numbers to support a finer level of grading. This apparently glaring inconsistency was raised in a number of submissions.

There are a number of assessment tasks counting towards a final assessment in each of the in scope subjects. When it comes to combining evidence across assessment tasks, research suggests that the simplest, most reliable and fairest method is simply to sum the marks awarded for each of the tasks. This is the approach taken in New South Wales and Victoria (with moderation built into the process). But ACER advises:

*One shortcoming (of this approach) is that percentages do not represent absolute standards of achievement. What it means to have 85 per cent of questions right on a test or examination depends on the difficulty of the particular questions asked. In practice, it is possible to write both easy questions and hard questions that address the same syllabus, and it is almost impossible to develop two tests with identical difficulties. This means that there is no guarantee that a score of 85% on one test represents the same level of achievement as 85% on another test addressing the same syllabus. If tests become progressively easier year after year, the distribution of students' percentage scores can be maintained over time while absolute levels of achievement steadily decline. This is a problem with examination systems that report student results only as percentages: they have no straightforward way of measuring changes in standards over time.*³⁹⁰

A second shortcoming of percentages is that they generally do not provide substantive information about what exactly a student has achieved. For example, a score of 85% is difficult to interpret substantively because a score of 85% on an easy test represents a lower level of knowledge, skills and understandings than a score of 85% on a harder test.

Another complication, as teacher Mr Peter Thomas advised the committee, relates to the level of discernment that can really be applied when measuring work that requires some form of subjectivity (such as the 'higher order' criteria):

*By the 1960's, most researchers were agreed that subjective assessment of "value-judgement" work might be done on a five-point scale at the very best. Research demonstrated that markers, no matter how experienced, were not able to discriminate such work into more than five broad bands, thus making a nonsense of allocating a percentage mark (i.e. division into 100 bands) to it.*³⁹¹

³⁹⁰ Submission 58, ACER, pp3-4

³⁹¹ Submission 39, Mr Peter Thomas, p2

Queensland introduced the ‘criteria’ and ‘standards’ approach in part to overcome these problems.³⁹²

ACER suggests that numeric marking should be used at the task level, where it is appropriate for measuring assessment in the task domain; and that a qualitative approach should be taken to overall assessment:

*... the approach to combining evidence from multiple sources or to aggregating scores needs to be appropriate to the assessment method. In Queensland there seems to be a philosophical opposition to arriving at on-balance conclusions numerically. Although some rule based decisions are made, the practice is to use teacher judgement to arrive at overall conclusions. Teachers have got the message, whether intended or not, that they should not be calculating test scores. The change that is required here is a recognition that for some kinds of tasks such as tests the best way to reach an overall result is simply to add results on individual test questions and then to interpret the resulting scores qualitatively by reference to the exit levels of achievement and standards as set down in the syllabuses.*³⁹³

Committee comment:

It seems that the QSA and the teachers who are proponents of numerical marking are talking at cross-purposes. Mrs Walton’s advice was that numeric symbols may be used in place of alphabetical ones, as long as they relate to the standards. However using numbers to represent different standards is not the same as using numbers as numbers, which can be added to provide an overall indicator of achievement against the standards. The whole purpose of numerical marking is to allow summing of marks. This apparent miscommunication – referred to by one teacher and review panellist as a “*distortion of terminology*”³⁹⁴, and by others less generously, has clearly caused considerable angst for a large number of submitters to this inquiry.

Some of the confusion seems also to arise from a failure to distinguish between numerical marking at the task level, and at the overall assessment level.

The committee believes a combined approach that allows numeric marking where that is appropriate for individual assessment tasks is compatible with a standards-based system and should be encouraged where it supports teachers and students.

Numerical marking can be much more precise, in terms of expressing the extent to which a student has achieved a specified outcome. Precision is workable in mathematics, chemistry and physics if what is being taught is simple content knowledge. But where higher order skills like analysis, communication, synthesis are being taught, as they are in the Queensland and the national curriculum for P-10, the assessment system does need to reflect a greater degree of subjectivity, while minimising the impact of subjectivity on the overall assessment. This highlights the importance of moderation.

This, combined with more clearly defined criteria and standards, would reduce some of the burden associated with assessing student’s tasks, increase consistency between

³⁹² Submission 58, ACER, pp3-4

³⁹³ Hansard, 5 June 2013, Dr Gabrielle Matters, p15

³⁹⁴ Submission 175, Mr Anthony Lewis

assessments, and be fit for purpose in that it would ensure the most appropriate method of assessment can be used for the task at hand.

A more detailed description of standards would help to ensure greater assessment consistency and precision, irrespective of whether numbers are assigned to those assessments.

Numeric marking can be used readily to give weighting, removing the confusion that appears to arise from having B or C level questions (see Chapter 10).

Assessment tasks are not weighted at present. Similarly, all three criteria for the mathematics, chemistry and physics are considered equally important.

An element of numeric marking, where appropriate, could support weighting of the various assessment tasks, to direct student and teacher effort, and weighting of the three criteria for the subjects, to even further direct the focus of what is taught and learnt in terms of the relative focus on lower order and higher order skills.

The committee can see no reason why numeric marking cannot be used to represent the various standards of achievement in a manner similar to that used in Victoria and illustrated on pages 120-121. This would support summing across tasks using numbers, rather than attempting to do that with non-numerical indicators, should a decision be made to do that at some future point.

Recommendation 13:

The committee recommends that in the context of standards-based assessment, numerical marking be strongly promoted in maths, chemistry and physics alongside more specifically defined syllabus documents (see Recommendation 6) that include mark ranges to equate to each of the five standards of achievement for each criteria, to:

- a) increase clarity for students and teachers as to why particular standards of achievement are awarded
- b) ensure an appropriate focus is placed on content knowledge along with the higher order skills (numerical marks readily allowing weighting)
- c) reduce workload for teachers
- d) enable employers and universities and importantly, students themselves to readily see what content a student knows and does not know.

12 Moderation

Moderation is a key part of ensuring the validity and reliability of an assessment system. To moderate an assessment is to ensure that it is not extreme: that it is comparable and made consistently on the same basis as other assessments.

*Comparability of results is always important when assessment, whether through public examinations or externally-moderated school-based assessment, is used for publicly defining and reporting students' achievements in the courses they study. In the context of senior secondary certification, results recorded on certificates should (unless specifically identified otherwise) be comparable from person to person, from year to year and from provider to provider. In this context, two results that appear on a certificate to represent the same achievement in the same course should in fact represent essentially similar achievement, even where the forms of assessment were different and the assessment took place in different years.*³⁹⁵

Hill et al (1997) discuss the relative merits of the different approaches to what they call “the dilemma ...of ensuring fair and authentic assessment in an increasingly high-stakes environment” – a dilemma because on the one hand, school-based assessments improve the link between the curriculum and assessment processes and support the learning of concepts and capabilities “that are not so amenable to pen and pencil examinations”; but on the other, they are operating “in the context of constrained budgets, higher enrolments, and increasing reliance by employers and tertiary institutions on Year 12 certification....”.

Queensland uses an approach to moderation known as social moderation, in contrast to statistical moderation:

*The possible forms of validating teacher judgments at the marking stage are statistical moderation and social moderation. Linn (1993) refers to moderation involving human judgments as social moderation. He contrasts this with statistical moderation where adjustments are made to sets of scores to make them comparable or equivalent in some way. An example of statistical moderation is adjusting a school's internal assessment scores in a subject against the distribution of external examination scores for that group of students in that subject. Statistical adjustment of this kind is best referred to as “scaling”.*³⁹⁶

Where an external exam is used (such as in Victoria or New South Wales), comparability is sought through both the use of common syllabus and assessment approaches within schools (including moderation panels) and by statistical moderation whereby the results of a student's school based assessment are adjusted using a formula that balances it with the student's results on an externally set exam.³⁹⁷

³⁹⁵ Marion, Scott F, Peck, Bob and Raymond, Jan, 2011. Year to year comparability of results in Queensland Studies Authority senior secondary courses that include school-based moderated assessments: an ACACA sponsored review, p2

³⁹⁶ Matters, Gabrielle. Linking school-based assessment with public examinations: Role of moderation – principles, policy and practice. ACER, <http://www.acer.edu.au/document/Gabrielle.Matters.pdf>

³⁹⁷ Hill, Peter; Brow, Tim; Rowe, Kenneth and Turner, Ross, 1997. Establishing comparability of Year 12 school based assessments. In Australian Journal of Education, Vol 41, No 1, 1997, pp28-29

In Queensland, moderation occurs in the context of a school-based assessment system. In order to ensure that the levels of achievement match the requirements of syllabuses, and that levels of achievement are comparable across the state, the QSA conducts seven phases that together form the moderation process. They are:

- syllabus development
- work program approval
- monitoring
- verification
- comparability
- confirmation
- random sampling.

The Queensland moderation system has been shown by a range of studies to result in valid assessments.

Mrs Walton provided the committee with a detailed description of the moderation process, outlining what happens at each stage:

The moderation process starts with the school's work program being approved by a district or panel chair. Schools then submit student work at the end of year 11 for panels of teachers external to that particular school to monitor standards. Well over 8,000 submissions, each of which contains the work of five students, are reviewed across all authority subjects. Work is again submitted to panels of teachers external to the particular school at a point in year 12 to verify standards and levels of achievement for certification processes—again, over 8,000 submissions across all authority subjects. In addition, and prior to awarding the final levels of achievement to year 12 students across the state, state panellists perform another layer of scrutiny. They check state-wide comparability through the review of over 700 folios of student work checking across levels of achievement. A final check is carried out by officers of the QSA to ensure that schools have acted on moderation advice.

After year 12 students have graduated, an additional check on the health of the system is carried out when a random sample of student work is reviewed. Over 2,500 individual folios from over 200 schools are sent to panels of teachers in different districts across Queensland to review the final levels of achievement—as I mentioned earlier, rigorous peer review of teachers' judgements by teachers. Fifteen years of data shows that teachers consistently achieve a high rate of agreement in the assignment of levels of achievement.³⁹⁸

The benefits of this moderation process were summarised by Mrs Walton, for the QSA, as follows:

There are three benefits. Firstly, students benefit from the frequent and detailed feedback on their work and their higher order thinking skills are developed. Of course, they are not subject to one-off high-stakes examinations that

³⁹⁸ Mrs Walton, Hansard, 7 March 2013, p4

*determine their final grades and immediate prospects for tertiary study. Secondly, the system builds the professionalism of our teachers by encouraging their ownership in the assessment process and making them accountable for their judgements. Thirdly, government benefits from a system that is fair, reliable and highly cost-effective.*³⁹⁹

In respect of validity, Mrs Walton pointed out that:

Fifteen years of data shows that teachers consistently achieve a high rate of agreement in the assignment of levels of achievement. The system is consistent within itself and across time. An independent review conducted in 2011 by US assessment expert Dr Scott Marion and two senior experts from the Victorian and South Australian qualifications authorities found that Queensland's current procedures for ensuring both the within year and year-to-year comparability were strong overall. This is not surprising because Queensland teachers have all that they need to make valid and reliable judgements: syllabuses to provide them with the knowledge about what they should teach, standards to use in assessing student achievements and a moderation system to provide opportunities for professional discussions with other teachers about the standards evident in their students' work.

Some of the complaints about the review panel process are that disagreements between panel members or between the panel and the assessing teacher indicate that there is a high degree of subjectivity and thus, there is a lack of reliability in the assessment process.

However, the moderation process is deliberately about debate and discussion. Disagreements and their resolution actually demonstrate *“how the system works to make sure mistakes are corrected and to get the right outcome for the student”*.⁴⁰⁰ That is exactly how the result is actually ‘moderated’ in this model.

The fact that timeframes are often tight, however, can mean that *“there is a degree of pressure to reach a conclusion so that certification can proceed”*.⁴⁰¹

Examples have been given to the committee about inconsistencies from year to year in terms of what standards of achievement constitute an A, B, C and so on. For example, a teacher of 28 years, who is also a head of department, told the committee that panellists make inconsistent judgements, *“An assessment package will be accepted one year, but rejected the following year. Individual panellists have differing opinions regarding the criteria statements.”*⁴⁰²

Queensland Teachers’ Union told the committee that implementation of the new syllabuses for science and mathematics was *“... complicated by a lack of adequate support by the QSA and inconsistent interpretations of the syllabus requirements by QSA officers and district review panels.”*⁴⁰³

A similar view was expressed by a mathematics and chemistry teacher who has over 30 years of experience:

³⁹⁹ Mrs Walton, Hansard, 7 March 2013, p4

⁴⁰⁰ Submission 12

⁴⁰¹ Scottish Qualifications Authority, 2008. Policy and New Products, Research Report 1 – The assessment systems of Finland and Queensland, p9

⁴⁰² Mr Paul Young, Submission 240, p2

⁴⁰³ Queensland Teachers’ Union, Submission 26, p2

*Huge variation occurs between schools as no two schools have exactly the same course (curriculum, topics studied or assessment tasks) and a very limited amount of time is available for District Review Panel members to review submissions. The feedback from the Review Panel from year to year can be inconsistent, with assessment tasks that were satisfactory last year no longer being seen as satisfactory this year, under the same syllabus.*⁴⁰⁴

A mathematics and physics teacher, who is also a panellist, identifies issues with the moderation process, including inconsistencies in the views of panellists:

... since the implementation of the 2007 syllabus, the process is simply disheartening and frustrating year after year ... I find it extremely difficult to give quality feedback to schools. To have two hours to understand the assessment package from a school and be able to verify the standards of 9 folios is virtually impossible. The length of the EEs makes this process harder still. Rarely do I only spend 2 hours reviewing a submission to a standard that I am comfortable with. As a result of the vagueness of the exit standards and the unrealistic time restraints, Panel feedback comes down to the opinion of the Panellist who is the most vocal or is more passionate about getting their point across ...

*This is not due to a lack of professionalism or competency of Panellists. The main problem with this process is the subjectivity in the assessment judgements and the exit standards making useful and accurate feedback very difficult to give and the length of some assessment items. To give Panellists more than two hours to review submissions is not preferable for already busy teachers; the syllabus should be reviewed to make it more clear and economical and workloads should be made realistic for students, teachers and Panellists.*⁴⁰⁵

In a standards-based system, one would expect the standards to be fixed and constant. To have an expectation that an A one year is equivalent to an A the following year does not seem unreasonable. However it is not clear whether any variation from year to year is more or less likely in a statistical moderation model than a social moderation model.

A (small) external review of Queensland's social moderation model in 2011 found that it did indeed achieve a high level of comparability between schools and between years, and that it could benefit from "seeding" work from previous years into the current year's moderation processes. This would be a direct approach to evaluate the degree to which standards are maintained across years.

Review panels are staffed by teachers who have been trained and who have the right skills, experience and interests. This process of 'credentialing' is undertaken by the QSA.⁴⁰⁶

The review panel approach allows professional judgements to be made by teachers, and supports professional development by raising awareness about how standards should be applied.⁴⁰⁷ However they are resource intensive and *"the potential exists for significant inflation of grades as teachers seek to enhance student's prospects of a place in higher*

⁴⁰⁴ Name suppressed, Submission 152, p2

⁴⁰⁵ Mr Brendan Maher, Submission 215, p4

⁴⁰⁶ Queensland Studies Authority, September 2010. Moderation Handbook for Authority Subjects, p29

⁴⁰⁷ See QSA submission and briefs; Hill et al, 1997

education".⁴⁰⁸ Furthermore there can be the predictable issues of human differences of opinion and relative power. A key criticism in submissions is that results are not comparable from year to year, because they are so dependent on the opinions of each year's individual panel members.⁴⁰⁹ The 2011 report on the system would actually seem to support that suggestion, commenting that:

The Queensland system rests on the expertise and commitment of the panellists (who conduct moderation meetings) and it is clear that QSA recognizes and supports the need to maintain a high level of expertise among its panellists.⁴¹⁰

In Victoria, review panels audit samples of school-based assessments. However they act in an advisory role and have no power to alter grades.

The teachers with whom the committee met in Victoria and in New South Wales were strongly supportive of the external exam system, and the review panel model within the Victorian audit system, as an excellent form of professional development.⁴¹¹

Committee comment:

The committee recognises the value of school-based assessment for enhancing assessment for learning. It also acknowledges that participating on review panels enhances teacher quality, offering professional development which is key to good outcomes for students.

However, it seems that some of the strengths of the social moderation system – in particular its strong focus on people and on their expertise and commitment – might actually also be its weak point. The misunderstandings expressed about how social moderation works, through debate and discussion, are of concern; and reports that people feel intimidated and pressured is a direct function of the model being dependent on human interaction. This is not an inevitable feature of a social moderation model, and in part it appears to have arisen in a context of poor communication and some consequent 'bad blood' between those who participate in and oversee the process, and some teachers.

The committee believes that exam setting, and exam marking can also offer a high level of professional development.

The committee questions the ability of review panels to adequately moderate assessments between schools in the absence of any common assessment tasks, and in the context of the low level of detail about the standards provided by the syllabus. It particularly notes the potential for these factors to impact on the validity of panel moderated assessments. However it does note the value of panels developing and reviewing common assessment tasks, and moderating them as a means of professional development in conducting assessment.

The committee is inclined to agree with the observations of Dr Gabrielle Matters⁴¹² that there is a philosophical preference in Queensland for particular approaches to assessment. It should be possible to achieve similar outcomes in terms of using assessment for learning, and ensuring professional development for teachers, through a statistical moderation process as would be provided by having an external subject-based exam contribute to part

⁴⁰⁸ Quality of Education Review Committee, 1985 cited in Hill et al, 1997

⁴⁰⁹ See for example, Submissions 26, 152 and 215

⁴¹⁰ Marion et al, 2011, p4

⁴¹¹ Private conversation, 30 August 2013

⁴¹² See pages 81, 113, 120 of this report

of student's assessment and to scale school-based assessment (see Recommendation 4). An external exam has the benefit of ensuring a degree of commonality in terms of assessment tasks, which can only enhance validity of that component of the assessment.

Recommendation 14:

The committee recommends that a (reduced) mechanism to enable teachers to set and review school-based assessment tasks should continue to operate for senior mathematics, chemistry and physics, but that this mechanism not be used to moderate school-based assessments.

13 Cost implications

The costs and benefits of different approaches to assessment and moderation of assessment were raised during this inquiry. Consequently the committee has given them some consideration, but believes this will be a focus of inquiry for the government-commissioned inquiry into senior assessment and tertiary entrance regimes. It offers the following observations, however.

The range of controls and checks implemented to ensure the school based system is robust, comes at a cost. The panel system is expensive, offering a lot of intervention and control over the assessment system. The Queensland Core Skills Test is another cost. As well there appear to be significant costs to teachers in terms of time, in being fully responsible for student assessment.

Importantly, the QSA already sets an external exam for senior mathematics A, B, C, chemistry, and physics in Queensland. This is described in part 1 of this report.

Maxwell and Cumming identify overall costs as an often raised issue that might detract from the externally moderated school-based assessment system for Years 11 and 12 in Queensland, however they dismiss this issue as a serious concern:

*Costs are difficult to estimate because some are hidden. Apart from the direct costs of the central authority, schools contribute to the system through staff time—in conducting assessment and through participation in moderation processes. Even considering these hidden costs, any reintroduction of public examinations would cost more in government expenditure. Also, against the costs of the system must be placed its benefits in teacher professional development, stemming both from the constant challenge to teachers to rethink and improve their professional practice and from teacher participation in the moderation processes. Review panels are powerful agents of professional development for teachers through direct acquaintance with practices in other schools, the opportunity to discuss assessment issues, practices and standards, and a continual focus on quality and improvement. Schools value their teachers' membership of review panels for this reason—the benefits outweigh the costs.*⁴¹³

In a World Bank publication, Dr Reg Allen discusses the origins of Queensland's school-based assessment system, noting the reasons why the system gained favour, including: "Low direct costs due to teachers carrying out the assessment activities as part of their regular job..."⁴¹⁴ He highlights reasons why Queensland suits the use of a local district model, with state supervision of the comparability between districts, also noting that: "There are costs associated with this, of course, but the use of a central model would remove the need for teachers to take responsibility of their judgments of standards."⁴¹⁵

Dr Allen argues that it is not easy to estimate the total costs of the school-based assessment and moderation program in Queensland:

⁴¹³ Graham S. Maxwell and J. Joy Cumming, *Managing without public examinations: Successful and sustained curriculum and assessment reform in Queensland, Australia's Curriculum Dilemmas*, pp200-201, 2011

⁴¹⁴ Reg Allen, *Developing the Enabling Context for School Based Assessment in Queensland*, Australia, p6

⁴¹⁵ Ibid, footnote 13, p6, 2012

From one perspective, a full costing of the program would include the costs of teachers' time in preparing work programs, assessing student achievement, and contributing to the processes that ensure adequate comparability of statewide results. From another perspective, virtually all of these items are part of the role teachers do or should carry out in the normal course of their professional work. These are not part of the expenditure of the central authority, and are not in the cost estimate that follows.

*The following cost estimates are intended to cover all direct costs related to certification of senior secondary school subject results and the determination of a rank for use in selection for tertiary education. The current approximate annual expenditure of QSA on externally moderated, school based assessment is US\$19 million, of which the external assessment for scaling (Queensland Core Skills test) accounts for around US\$5.3 million and the external moderation program for around US\$10.7 million.*⁴¹⁶

Dr Allen claims that Queensland's school-based assessment program appears to be cheaper than traditional external examination programs used for the same purpose:

*In fact, the current direct cost per student assessment (one result in one subject for one student) appears to be about US\$70. The school based assessment program in Queensland is less than 60 per cent of the estimated cost per student assessment of a comparable external examination program in Australia.*⁴¹⁷

Karen K K Chong of the Singapore Examinations and Assessment Board states that: "The assessment of oral presentation being resource intensive in terms of time and personnel, it is more pragmatic and cost efficient for assessment of this performance component to be carried out by the teachers within the school."⁴¹⁸

In material on its website, the QSA advises that the Queensland system meets the criteria for an ideal assessment model, as defined by international assessment expert Dylan William (2008), who advocates a system that is, among other things, manageable:

*...so that costs are proportionate to benefits. The dollar cost of the Queensland system is significantly less than budgets for end-of-year external examinations, but the benefits for professional development of our teachers far outweigh budget savings.*⁴¹⁹

Dr Kevin Donnelly, an education commentator and consultant claims that school-based moderation: "...is costly, ineffective and educationally unsound [which] explains why Victoria, after experimenting with such an approach during the early 90s, abandoned it in favour of the more traditional end of year, externally set and marked formal examinations."⁴²⁰

⁴¹⁶ Ibid, p11

⁴¹⁷ Ibid

⁴¹⁸ Karen K K Chong, Whither School-Based Coursework Assessment in Singapore?, 35th IAEA Conference – *Assessment for a Creative World*, p5, September 2009

⁴¹⁹ Queensland Studies Authority, *School-based assessment – The Queensland System*, p13, 2010

⁴²⁰ Dr Kevin Donnelly, *External beats internal*, On Line opinion, 19 April, 2013, www.onlineopinion.com.au/view.asp?article=14921&page=0

New Zealand scholars identify claims that standards-based assessment is costly to implement:

*It is time-consuming in absolute terms, for both candidates and assessor and it imposes major costs in terms of equipment, provision of wide-ranging assessment situations, and repeated evidence of mastery. Accordingly, the provision of adequate resourcing must be a major policy decision for any organisation seeking to successfully implement SBA.*⁴²¹

An OECD policy document refers to costs when comparing different forms of system performance monitoring based on national assessment programs:

*Periodic sample-based student tests can allow greater breadth of measurement, fuller coverage of the curriculum and avoid distortions deriving from 'teaching to the test'. They can be carried out at comparatively low cost. By contrast, full cohort student tests have the advantage of potential feedback to schools on classes/students, but are narrower measures that cannot realistically include a full coverage of the curriculum. Large-scale standardised tests are often limited to written formats such as multiple choice or short essay questions that are easiest to score and most cost-efficient to implement: such tests may only draw upon a limited set of students' skills.*⁴²²

However the committee points out that this must be considered in the context of what the curriculum actually covers. Curricula which focus more heavily on the content knowledge than on higher order skills, may lend themselves quite readily to large-scale standardised tests. However such tests do not support the ability of teachers to use assessment for learning.

The Stanford Centre for Opportunity Policy in Education, which has undertaken research into the costs and expenditures relating to assessment systems in the United States, states that:

As a general rule, performance assessments⁴²³ are more expensive to score than multiple choice tests. However, there is considerable variation in scoring costs based on the nature of the performance and the nature of the score(s) to be assigned. For example, the cost of scoring student written essays was estimated to be between \$1.47 and \$5.88 per student (Hardy, 1995). Similarly, the cost for scoring the Iowa writing assessment was estimated to be about \$5 per student (Hoover et al.). On the other hand, scoring costs for the hands-on science tasks... were two or three times as much, ranging from \$9 to \$15 per student (Stecher & Klein, 1997)...

⁴²¹ Peter Rawlins, Jill Brandon, Jan Chapman, Linda Leach, Guyon Neutze, Adele Scott, Nick Zepke, *Standards-Based Assessment in the Senior Secondary School: A Review of the Literature*, New Zealand Journal of Teachers' Work, Volume 2, Issue 2, p109, 2005

⁴²² OECD Education and Training Policy Division of the Directorate for Education, *Evaluation and Assessment Frameworks for Improving School Outcomes Common Policy Challenges*, p8, 2011

⁴²³ Performance assessment is defined as assessment which judges student achievement on the basis of relatively unconstrained responses to relatively rich stimulus materials; it gained increasing favour in the United States in the late 1980s and 1990s; at least one national commission advocated the replacement of multiple-choice tests with performance assessments; the National Assessment of Educational Progress conducted extensive pilot testing of hands-on assessment tasks in science and mathematics (Educational Testing Service, 1987) and performance assessments were adopted by a number of state testing programs.

*Ultimately, policymakers would like to know whether the benefits of performance assessment (in terms of more valid measurement of student performance, positive impact on classroom practice, etc.) justify the burdens (in terms of development costs, classroom time, scoring costs, etc.). This review suggests that the expenditures and administrative burdens associated with performance assessments, particularly portfolios and extended hands-on science tasks, were high relative to multiple-choice tests. Yet, that is not the end of the story.*⁴²⁴

The report continues by noting that the educational benefits of performance assessment may justify its burdens and that the costs associated with performance assessments have probably declined over the past decade, making it more attractive to incorporate some degree of performance assessment into state testing programs.⁴²⁵

In considering the costs of standards-led assessment, Linn and Herman, in a University of California publication, note that the costs vary widely, depending on the number and length of responses to be judged, the number of judges or scorers, the number of content areas assessed, the number and nature of reports to be produced, and the inclusion of “practice assessments” and other preparation materials:

*It is clear, however, that assessments requiring extended student responses – to be judged by teachers or other subject-matter experts – usually cost more than multiple-choice tests, which can be scored by machines... Assessments that require a mix of short answers and extended written responses can easily cost two or three times as much as machine-scorable tests... And the costs of more elaborate performance assessments – involving, for example, hands-on science tasks – are substantially higher...*⁴²⁶

This information is presented to inform any further action that might be taken by the government in respect of costing assessment models.

⁴²⁴ Stecher, *Performance Assessment in an Era of Standards-Based Educational Accountability*, Stanford Centre for Opportunity Policy in Education, Stanford University, pp28 & 29, 2010

⁴²⁵ Ibid, p29

⁴²⁶ Robert L. Linn and Joan L. Herman, *Standards-Led Assessment: Technical and Policy Issues in Measuring School and Student Progress*, CSE Technical Report 426, pp 20-21, 1997

14 Support for teachers and schools

A group of academics at the expert advisory forum advised the committee that:

.... the quality of teaching that students experience is absolutely crucial. There is a large amount of rigorously conducted research around that demonstrates that teachers do make a difference to student learning. So it is important that teachers know how to design assessment tasks, that they know how to teach students how to respond appropriately to those tasks and that they know how to make sound judgements of students' learning based on those tasks. So we ended up by asking: what do teachers need in order to be able to do those things? Firstly, they need time. They also need resources, advice, examples, professional development. The experience of social moderation where they sit down with other teachers to examine students' work and come to a consensus professional judgement about that work is also extremely valuable preparation and training for teachers in making good assessment decisions.⁴²⁷

A view was expressed by some academics from the maths and science disciplines as well as those from schools of education and some teachers that professional development for teachers is required, to improve their understanding of the standards and criteria outlined in the syllabus and how to apply them. For example:

Some [of our] implicit recommendations⁴²⁸ really related to professional development for teachers who may be having difficulty or facing challenges with criterion referenced assessment.⁴²⁹

The Queensland Independent Education Union shared a similar view:

Many appear not to comprehend fully how criterion can be differentiated to determine the difference between the different levels of achievement – the VHA, or the HA, and so on – at exit standard and even on individual assessment tasks. Some criteria in particular seem to be a little more difficult than others and I am thinking particularly of the communication criteria quite often.⁴³⁰

An inference could be taken that teachers who do not support the standards, do not understand them, and this was strongly rejected by others. Teacher Ms Maureen Anderson, responded to this suggestion, saying:

We are not saying that we do not know the system. We are saying that we cannot cope with that and teaching as well. To teach effectively you need to clear your mind. We are finding that the assessment is overtaking the time that we have to teach. I will give you some examples from some of the submissions.

The QUT states –

The concerns of teachers should not surprise given that most secondary chemistry and physics teachers have not had science research careers...

Griffith University states –

⁴²⁷ Hansard, 1 May 2013. Professor Merrilyn Goos, p5

⁴²⁸ See submission 121

⁴²⁹ Hansard, 10 July 2013, Professor Al Grenfell, p3

⁴³⁰ Hansard, 22 May 2013, QIEU, Ms Miriam Dunn, p6

...it is crucial to the rollout of change that adequate professional learning is made available..

The University of the Sunshine Coast states –

Ongoing professional development for teachers in understanding and enhancing their expertise...

We are not saying we do not know how to do the system; we are saying that we cannot teach effectively with this onerous assessment regime. That is what has been said throughout the submissions....I do take a bit of offence that I just need more training and I will be better in the classroom. I was an industrial chemist and I did do research before I went into teaching. I do have the full subject knowledge. I find that focussing on assessment as opposed to teaching takes away from my first love, which is my subject.⁴³¹

While there may be room for improved training (ie professional development) for teachers in relation to assessment processes and methods, particularly for the large number of teachers who do not have tertiary qualifications in the subjects they are required to teach (see chapter 15), it seems to the committee that the issues being raised should be addressed by improving the clarity and detail given about the standards in the syllabus, and promoting the use of numerical marking where that is appropriate – giving guidance as to how to use it in the context of a standards-based system.

One teacher, Mr Clinton Jackson, submitted that better support for teachers, especially where non-specialist teachers are teaching these subjects, could include developing centrally more ‘off the shelf’ assessment packages and tools, and establishing a bank of generic tasks:

Many schools rely on nonspecialist teachers to cover senior classes, particularly in smaller schools and remote schools. These teachers lack the content expertise to develop rich, authentic and localised units of work that connect to the wider body of content knowledge. The availability of more “off the shelf” units of work and assessment would also assist these teachers.

The QSA could collate and publish sets of generic questions from year to year that teachers could use as a resource for their own preparation and that for their students without impairing the integrity of the individualised work programmes.⁴³²

Committee comment:

There is no requirement in Queensland for teachers of mathematics, chemistry or physics to have tertiary qualifications in those fields. Principals make decisions about teacher allocation in the context of available teachers and school priorities. Anecdotally, it appears that many teachers are teaching outside their field. The committee is concerned that there is insufficient clarity in the syllabus documents to support a non-specialist teacher to:

- set assessment tasks that appropriately assess the criteria
- interpret the requirements for the five standards of achievement for each criteria in undertaking assessment.

⁴³¹ Hansard, 22 May 2013, Ms Maureen Anderson, p11

⁴³² Submission 151, Mr Clinton Jackson

The combination of teachers lacking in specialist qualifications and very non-prescriptive syllabus, has the potential to impact on workload, stress levels, and the validity of the assessment which is carried out. It is easier to assess and moderate achievement on a common task. More detailed standards and changed work requirements for extended assessment tasks (see earlier recommendation) would also provide support for teachers.

Recommendation 15:

The committee recommends the QSA provide more direction to schools and teachers in respect of requirements for school-based assessment tasks, both in the syllabus documents and through training.

See also Recommendation 11, establishing a catalogue of common assessment tasks.

15 Teacher qualifications

That there is a shortage of teachers qualified in mathematics and sciences is well documented. In its 2012 *Schools Workforce* research report, the Commonwealth Government's Productivity Commission observes that there have been persistent shortages of suitably qualified teachers in various secondary school subjects, including mathematics and science⁴³³:

Some of the subject-based shortages are estimated to be substantial. For example, about three-quarters of mathematics department heads surveyed by Harris and Jensz (2006) experienced difficulty recruiting suitably qualified teachers....

*In some subjects — most notably mathematics and science — the magnitude of the shortfalls has apparently increased over time (Cairns 2007; Centre for the Study of Higher Education 2006; Eacott and Holmes 2010; Stokes and Wright 2007).*⁴³⁴

Dr B. J. Arnison OAM, whose professional experience in education spans more than forty years, including teaching secondary and tertiary mathematics, physics and chemistry, comments that: *"There is also a shortage of qualified mathematics and science teachers in difficult staffing areas across the state."*⁴³⁵

This is not a uniquely Queensland phenomenon. A recent report by the Victorian Auditor-General⁴³⁶ notes the same issue in that state – the education department *"does not have sufficient evidence to inform its workforce decision making"*⁴³⁷, when *"teacher quality is the single most important school-based factor influencing student interest and achievement"*.⁴³⁸

The impact of teachers lacking qualifications in the subjects that they teach is felt disproportionately in rural and regional areas. Rural and regional schools reportedly face difficulty with attraction and retention of teachers in general, and in particular those with specialist qualifications. At all schools, principals have to make decisions about where to allocate those qualified teachers that they do have (for example, is most benefit gained from allocating them to Year 8, to encourage engagement by more students at an early stage, or at senior level where the stakes are high, but student numbers may be lower because of the lack of earlier engagement?)

A number of initiatives exist at national and state levels to try to address the shortage of teachers with specialist qualifications.

The Queensland Government's *'A Fresh Start: improving the preparation and quality of teachers for Queensland schools'*⁴³⁹ contains initiatives including 'New pathways into the teaching profession', which has the potential to attract professionals with relevant qualifications into teaching.

⁴³³ Productivity Commission, 2012, *Schools Workforce*, Research Report, Canberra, p89

⁴³⁴ Ibid pp89 & 90

⁴³⁵ Dr B. J. Arnison OAM, Submission 228, p20

⁴³⁶ Victorian Auditor-General's Office, 2012. Science and Mathematics Participation Rates and Initiatives

⁴³⁷ Ibid, pix

⁴³⁸ Ibid, pviii

⁴³⁹ DETE, 2013. <http://flyingstart.qld.gov.au/SiteCollectionDocuments/A-Fresh-Start-strategy.pdf>

At the time of writing, the Queensland Auditor-General is undertaking a performance audit in respect of the supply of specialist teachers, including mathematics, chemistry and physics teachers, in Queensland. The report of that audit is due to be tabled in the Queensland Parliament shortly after the committee's report in respect of its inquiry into assessment methods is to be tabled (ie. this report).

As performance data indicates (see Chapter 6) the supply of specialist teachers is also an issue at the primary school level. Any performance shortfalls for Queensland students (and Australian students) in mathematics and science begin well before the senior year.

Providing better support for teachers who lack specialist qualifications in the areas in which they teach is one rationale for the suite of recommendations proposed in this report.

The committee looks forward to reviewing the Auditor-General's report on how the government is progressing with respect to improving the supply of specialist teachers in Queensland.

16 Developing the evidence base

A striking aspect of this inquiry was the strength of opinion about assessment methods used in senior mathematics, chemistry and physics in Queensland schools – and the commensurate lack of empirical evidence. As pointed out by Dr Gabrielle Matters during this inquiry:

*... good assessment or assessment that is described as good can only be described as good if there is an empirical basis for that statement. Two aspects or two questions that will be asked in order to answer the two questions that lead to the conclusion that the assessment is good, the assessment is of high quality, need to be grounded in fact, that people do understand the aspects of the system that they have opinions about; and No. 2, that there is an empirical base for answering the question, 'Is the Queensland system functioning well?'*⁴⁴⁰

This is a multi-faceted question and answering it is a complex task. Cause and effect is not necessarily clear. Agreement would be required about what makes an assessment system 'good', and that is affected by what the purpose of the assessment system is (which in turn is determined by what the purpose of the education system is). The committee has raised some of these issues throughout this report.

The world-renowned and highly reputable International Baccalaureate Organisation (IBO) sees that interpretation of results, and what they are used for, is a key determinant of whether or not any given approach to assessment is valid. Different skill areas and contextual frameworks make precise objective measurement impossible. And, student capability is variable depending on the assessment task used, and the point in time. Because capability and time is not static, measurement can't meaningfully be precise. But, it is acknowledged there is a need to make the results as dependable as possible.⁴⁴¹

The committee has identified in Chapter 5 that changes in participation rates for senior mathematics, chemistry and physics cannot be causally linked to changes in the assessment methods used for those subjects.

The committee has identified in Chapter 6 that comparison of outcomes for students, particularly at the senior level, is not possible. This makes it very difficult to ascertain whether assessment methods have differential impacts on student performance and thus, possibly, a causal relationship with performance.

There is also not a shared understanding about the purpose of assessment, teaching and learning in these subjects at senior level: whether it is for preparing students for further study, or as part of a broader education for mathematical and scientific literacy, or both.

The committee has recommended clarity be provided in this respect (see Recommendation 3).

Committee comment:

There is currently little to no evidence available about performance variations between different senior assessment systems. Data about senior performance between Australian jurisdictions and assessment systems is not comparable – due to different curriculums,

⁴⁴⁰ Hansard, 1 May 2013, Dr Gabrielle Matters, p3

⁴⁴¹ IBO p9

different assessment systems and different assessment tasks. Should changes to the senior assessment system be agreed, it is important to establish some benchmarks that will enable measurement of any resulting changes, and these benchmarks should be comparable with other assessment systems. The implementation of a national curriculum for senior mathematics, chemistry and physics would provide an opportunity for greater comparison.

Recommendation 16:

The committee recommends the government undertake research to establish benchmarks and, at an appropriate time, evaluate performance progress in Queensland and compare Queensland performance in senior mathematics, chemistry and physics (and all senior subjects) with the performance of senior students in other Australian jurisdictions and internationally.

17 Conclusion

A summary of the committee's findings in respect of each selection criteria is outlined below.

1. That the Education and Innovation Committee inquire into and report on the assessment methods used in Senior Mathematics, Chemistry and Physics in Queensland schools.

The committee has considered the assessment methods used in senior mathematics, chemistry and physics in Queensland schools, highlighting the issues identified by submitters to this inquiry.

The fundamental findings, applicable throughout all of the committee's consideration of the matters referred, are that:

- What is assessed, determines what is taught and what is learned. Assessment methods cannot be considered in isolation as it has implications for, and is affected by, teaching and learning.
- 'Fitness for purpose' is critical. Different methods of assessment are appropriate depending on what is being assessed, and the use to which the assessment is being put.
- The assessment system needs to be fit for purpose, to appropriately measure all of the exit criteria set for a subject.

2. That, in undertaking this inquiry, the committee should consider the following issues:

- Ensuring assessment processes are supported by teachers

Evidence presented to this inquiry suggests that there is a degree of frustration experienced by teachers of senior mathematics, chemistry and physics in Queensland schools. Anecdotally, teachers are not willing to teach these subjects. However no objective evidence to support that claim is available.

Some assessment processes are almost universally unsupported by teachers – in particular, that numerical marking cannot be used in these subjects (whether that is in fact a prescribed requirement or not, a ban on it is widely practiced). Another process identified as problematic by many submitters was the use of extended assignments as assessment tasks in these subjects. While most teachers acknowledged the value of such assignments, they did not support their use as prescribed at present in the syllabus documents, or the contribution they make towards a student's overall achievement grade for the subject. The reasons for this are discussed in this report. The key objection is the relative emphasis these tasks have on learning the content knowledge required for the subjects in question, given the way they must be undertaken.

- Student participation levels

In the context of a perceived decline in participation levels here and internationally, the data does not suggest there is a major decline in student participation levels for these subjects. The decline that does exist cannot be linked to the methods used to assess them – it is linked primarily to broader policy changes that have resulted in higher senior retention rates; and a greater range of subjects being on offer at that level.

- The ability of assessment processes to support valid and reliable judgments of student outcomes.

The committee considers that some assessment processes, as they stand, are limited in their ability to support valid and reliable judgements of student outcomes in senior mathematics, chemistry and physics. In part, this relates to a lack of support and a lack of understanding by teachers (including moderation panel members) of the assessment methods to be used; as well as to an insufficient level of detail being provided in the syllabus. It also relates to a lack of any common assessment tasks that allow direct comparability between the work of students at different schools.

Appendix A – List of submissions

Sub #	Submitter
1	Doug Goldson
2	Barry Flowers
3	Neil Capps
4	Name suppressed
5	Name suppressed
6	Mark Gould
7	Jason Smith
8	Name suppressed
9	Name suppressed
10	Rob Paterson
11	David Austin
12	David Madden
13	Matthew Hughes
14	Name suppressed
15	Arthur Galbraith
16	Submission withdrawn
17	William Moulds
18	Merv Myhill
19	Patrick Whalen
20	Robert Hill
21	Name suppressed
22	Jacqueline Easthope
23	Name suppressed
24	Elizabeth Henley
25	Cameron Ross
26	Queensland Teachers' Union
27	Name suppressed
28	Dr Matthew Dean
29	Stephen Kazoullis
30	Dr Stephen Norton
31	Professor Dirk Kroese
32	Kyle Hillcoat
33	Emeritus Professor Peter Fensham
34	Ian Watkins
35	Keith Smith
36	Greg Reinhardt
37	Tony Sanchez
38	Professor Igor Bray
39	Peter Thomas
40	Geoffrey Dean
41	Name suppressed

Sub #	Submitter
42	Christopher Blood
43	Steve Ryan
44	Barbara Wasley
45	Neil French
46	Kristan Ford
47	Dr Chris Meimaris
48	Adele Schmidt
49	Ian Sanderson
50	Professor Jennifer Stow
51	Name suppressed
52	Rex Boggs
53	Ian Pink
54	Queensland University of Technology
55	Bronwyn Booth
56	Stephen McIlhatton
57	Peter Antrobus
58	Australian Council for Educational Research (ACER)
59	Craig Fraser
60	Margaret Sullivan
61	Brendan O'Connor
62	Richard Hiatt
63	Shane Simonsen
64	Name suppressed
65	Name suppressed
66	Name suppressed
67	Ellie Goodwin
68	Leon Perry
69	Honorary Professor Peter Galbraith
70	Name suppressed
71	Michael Moy
72	Name suppressed
73	Matthew O'Connor
74	Dr Kevin Donnelly
75	Tony Chamberlain
76	Tanya Haggarty
77	Name suppressed
78	Andrew Jackson
79	Name suppressed
80	Bob Osmak
81	Therese Feldman
82	Mary Rofe
83	Shaun Fardy
84	Michael Mewing

Sub #	Submitter
85	Queensland Association of Mathematics Teachers (QAMT) - Cairns Branch
86	Carol McClymont
87	Name suppressed
88	Mark O'Connor
89	Peter Ellis
90	Name suppressed
91	Rebecca Andrews
92	Professor Helen MacGillivray
93	David Best
94	Jan Finch
95	Carlee Horton
96	Lawrence Knapman
97	Patricia OConnor
98	Professor Peter Ridd
99	Name suppressed
100	Steve Crapnell
101	Bronwyn Miller
102	Name suppressed
103	Name suppressed
104	Brad Ahern
105	John Ridd
106	Associate Professor Anthony Roberts
107	Name suppressed
108	Professor Marilyn Goos
109	Name suppressed
110	Austin Skinner
111	Patrick Whalen
112	Withdrawn
113	Richard Stokes
114	Jim Busuttin
115	Name suppressed
116	Lois Ward
117	Mark Grace
118	Liam OConnor
119	Paul Phiri
120	Ian Pink
121	Name suppressed
122	Faculty of Science, Health, Education, and Engineering - University of the Sunshine Coast
123	Bob Harvey
124	David Parrington
125	Confidential
126	Greg Comben

Sub #	Submitter
127	Andrew Ball
128	Name suppressed
129	Queensland Studies Authority
130	Nihal Palipane
131	Name suppressed
132	Carolyn Mcilvenny
133	Zoe Goodman
134	Dr Amitha Hewavitharana
135	Confidential
136	Andrew Findlay
137	Name suppressed
138	Maddie Horbury-Wood
139	Name suppressed
140	Name suppressed
141	Name suppressed
142	Name suppressed
143	Name suppressed
144	Ross Grimley
145	Fiona Hu
146	Chris Meagher
147	Name suppressed
148	Sarah Frost
149	Brisbane Catholic Education
150	Mitch Comben
151	Clinton Jackson
152	Name suppressed
153	Name suppressed
154	Jeff Close
155	Name suppressed
156	Kiri Vaughan
157	Mal Hartwig
158	Anthony Fraser
159	Name suppressed
160	Name suppressed
161	Teresa Gemellaro
162	Rod Siller
163	Name suppressed
164	John Mattick
165	Ray Minns
166	Joan Alavi
167	Name suppressed
168	Robert Nelder
169	Diane Arnold

Sub #	Submitter
170	Neil Daly
171	Name suppressed
172	Name suppressed
173	Dr Ian Wilson
174	Paul Bannister
175	Anthony Lewis
176	Dr Peter Darben
177	Denis Bridger
178	Phillippa Harvey
179	Debbie Lovell
180	Cathy Stone
181	Edmond O'Donovan
182	Ian Pink
183	William Hall
184	Name suppressed
185	Anne Gantimuroff
186	Name suppressed
187	Name suppressed
188	Name suppressed
189	Ron Addie
190	Sue Contarini
191	Jason Contarini
192	Andrew Foster
193	Andrew McCosh
194	David Watkins
195	John Clewett
196	Name suppressed
197	Sarah Chapman
198	Independent Schools Queensland
199	Name suppressed
200	Jill Rossner
201	Richard Porter
202	David Bruderlin
203	David Smith
204	Name suppressed
205	Julia Toft
206	Dr Tony O'Connor
207	Trevor Barrett
208	Anne D'Arcy-Evans
209	Name suppressed
210	Sonia Ballen
211	Simon King

Sub #	Submitter
212	Griffith University's Arts, Education and Law Group and Science, Environment, Engineering and Technology Group
213	Kay Anderson
214	Name suppressed
215	Brendan Maher
216	Windaroo Valley State High School
217	Name suppressed
218	Name Suppressed
219	Name suppressed
220	Professors Adams and Grotowski
221	Claire Wyatt-Smith
222	Noel Dickson and Jennifer Leung
223	James Penfold
224	School of Education, University of Queensland
225	Ramon Doon
226	Paul Sullivan
227	Name suppressed
228	Dr B J Arnison OAM
229	Professor Val Klenowski
230	Name suppressed
231	Name suppressed
232	Peter Finch
233	Torren Brennan
234	Carmel Nash
235	Name suppressed
236	Gary Turner
237	Barry Winning
238	Rod Cartwright
239	Graham Nielson
240	Paul Young
241	Name suppressed
242	Name suppressed
243	Queensland Independent Education Union
244	Nick Dubravcic
245	Damien Wallace
246	Science Teachers' Association of Queensland
247	Name suppressed
248	Michael Barra
249	Ros Eagles
250	Dr Gwen Lawrie and Dr Anton Rayner
251	Lorraine Petersen
252	Helen Stevens
253	Paul Evans

Sub #	Submitter
254	Julie Ryan
255	Australian Family Association
256	Mike Byrne
257	Connor Smith
258	Name suppressed
259	Dr Katherine Mainstone
260	Name suppressed
261	Mary-Ann Parlato
262	Kathleen Blum
263	Carolyn Matis
264	Michael Connor
265	Gordon Upham
266	School of Mathematical Sciences, Queensland University of Technology
267	Name suppressed
268	Ann Stoodley
269	Name suppressed
270	Megan Stuart
271	Name suppressed
272	Name suppressed
273	Trevor Jones
274	Ross Fanning
275	Dr Ashley Plank
276	Name suppressed
277	Leanne McCulloch
278	Name suppressed
279	Daryl Bathe
280	Alfred Smith
281	Maninder Pasricha
282	Confidential
283	Margaret McDonald
284	Name suppressed
285	Ray Hendle
286	Name suppressed
287	Dr Heather Row
288	Lisa Holmes

Appendix B – Witnesses at public briefings and public hearings

Witnesses at public briefing, Wednesday 6 March 2013

Department of Education, Training and Employment

Ms Robyn Rosengrave, Director, State Schooling Operations and Strategy
Ms Gabrielle Sinclair, Deputy Director-General, Policy and Programs
Mr Andrew Walker, Assistant Director-General, Strategic Policy and Portfolio Relations
Ms Annette Whitehead, Acting Director-General

Professor Peter Ridd, Head of Discipline, Physics, School of Engineering Sciences, James Cook University

Queensland Catholic Education Commission

Ms Mandy Anderson, Director
Mr Noel Covill, Head of Mathematics, St Joseph's College, Gregory Terrace

Witnesses at public briefing, Thursday 7 March 2013

Queensland Studies Authority

Ms Natalie Carrigan, Acting Manager, Quality Assurance Unit
Mr Theo Clark, Acting Manager, Australian Curriculum Branch
Mr Peter Jordan, Acting Deputy Director, Assessment and Reporting Division
Ms Leanne Rolph, Acting Assistant Director, P-12 Implementation Branch
Mrs Patrea Walton, Chief Executive Officer

Witnesses at public briefing, Wednesday 20 March 2013

Queensland Studies Authority

Ms Natalie Carrigan, Acting Manager, Quality Assurance Unit
Ms Jacqui Klowss, Head of Mathematics, Marist College Ashgrove
Mr David Madden, Head of Faculty – Sciences, St Aidan's Anglican Girls' School
Mr Bevan Penrose, Head of Department – Senior Schooling, Bundamba State Secondary College
Mrs Patrea Walton, Chief Executive Officer

Witnesses at public hearing, Wednesday 22 May 2013

Griffith University

Professor Clair Wyatt-Smith

Private capacity

Mr Brad Ahern

Ms Maureen Anderson

Mr Michael Barra

Mr Matthew Dean

Mr Andrew Findlay

Mr Mal Hartwig

Mr Chris Meagher

Mr Leon Perry

Queensland Independent Education Union

Ms Miriam Dunn, Research Officer

Dr Paul Giles, Assistant General Secretary and Treasurer

Queensland Teachers Union

Dr Peter Darben, Executive Member

Ms Leah Mertens, Research Officer

Queensland University of Technology

Professor Val Klenowski

Professor Helen MacGillivray

University of Queensland

Professor Peter Adams, School of Mathematics

Professor Joseph Grotowski, School of Mathematics

Dr Tony Wright, School of Education

Witnesses at public hearing, Wednesday 5 June 2013

Australian Family Association

Mrs Anita Bailey

Mrs Tempe Harvey

Hubbard's School

Mrs Helen Stevens, Principal

Private capacity

Dr Kevin Donnelly

Professor John Mattick

Science Teachers Association of Queensland

Dr Grant Darnell

Australian Council for Educational Research

Professor Gabrielle Matters

Griffith University

Professor Glenn Finger, Dean (Learning and Teaching), Arts, Education and Law Group

Witnesses at public hearing, Wednesday 10 July 2013

Teachers

Mr Peter Antrobus, teacher
Mr Paul Evans, physics teacher
Mr Anthony Fraser, teacher
Mr Robert Hill, physics teacher
Ms Lisa Holmes, mathematics teacher
Ms Alison McKenzie, teacher
Mr Ian Pink, teacher
Mr Steve Ryan, mathematics teacher
Mr Jeevan Soorya Dhas , physics teacher
Mr Paul Sullivan, teacher
Mr Dave Watkins, teacher

University of the Sunshine Coast, Faculty of Science, Education and Engineering

Professor Al Grenffell, Science Discipline Leader
Professor Noel Meyers, Head of School

Appendix C – Participants at expert advisory forum, 1 May 2013

The topic: The ability of assessment processes for senior maths, chemistry and physics to support valid and reliable judgments of student outcomes

Participants
<p>Dr Shaun Belward, Head of Discipline, Mathematics, James Cook University</p> <p>Dr Alberto Bellocchi, Lecturer, Faculty of Education, Queensland University of Technology</p> <p>Emeritus Professor Peter Fensham, Adjunct Professor, Faculty of Education, Queensland University of Technology</p> <p>Professor Merrilyn Goos, School of Education, University of Queensland</p> <p>Dr Carole Haeusler, Lecturer in Math, Numeracy and Science Education, Faculty of Education, University of Southern Queensland</p> <p>Professor Peter Jones, Head of School - Medicine, Bond University</p> <p>Ms Ailsa Leacy, Acting Institute Director, Southern Queensland Institute of TAFE</p> <p>Professor Euan Lindsay, Dean, School of Engineering and Technology, Central Queensland University</p> <p>Dr Gabrielle Matters, Principal Research Fellow, Australian Council for Educational Research</p> <p>Professor Peter Ridd, Head of Discipline, Physics, James Cook University</p> <p>Professor Halina Rubinsztein-Dunlop, Head of School of Mathematics and Physics, University of Queensland</p> <p>Professor Royce Sadler, Emeritus Professor, Griffith University</p> <p>Professor Robert Sang, Head of School of Science, Griffith University</p> <p>Dr Richard Walding, School of Biomolecular and Physical Sciences, Griffith University</p> <p>Ms Patrea Walton, Chief Executive Officer, Queensland Studies Authority</p>

Appendix D – Participants at study tour meetings

Participants at meetings, 29 August 2013, Sydney

Office of the Board of Studies NSW

Mr Tom Alegouanarias, President, Board of Studies
 Mr Andrew Goodyer, Manager, Strategic Policy and Planning
 Mr Anthony Drew, Deputy Director, Examinations and Credentials
 Ms Michelle Mitcherson, Head, Quality in Credentialling

NSW Secondary School Teachers

Dr Ric Morante, Head Teacher Science, Hurlstone Agricultural High School
 Ms Nikky Vanderhout, PTC NSW representative; Professional Learning Consultant
 Mathematical Association of New South Wales (MANSW); and former Maths teacher

Australian Curriculum, Assessment and Reporting Authority (ACARA)

Ms Deborah Lambourne, Chief Operating Officer
 Mr Peter Adams, General Manager, Assessment and Reporting
 Dr Kelvin Gregory, Senior Psychometrician, Assessment and Reporting
 Mr Goran Lazendic, Senior Manager Psychometrician, Assessment and Reporting
 Ms Melanie Isaacs, Senior Project Officer Science, Curriculum
 Ms Margaret Bigelow, Senior Project Officer Mathematics, Curriculum

Participants at meetings, 30 August 2013, Melbourne

Victorian Secondary School Teachers

Mr George Toth, Learning Leader: Mathematics, Kolbe Catholic College, Craigieburn
 Mr Ray Rozen, VCE Mathematics Co-ordinator (teaches VCE Year 12, Mathematical Methods and Specialist Mathematics RMIT University)
 Ms Kelly Gallivan, Middle School Studies Coordinator (teaches VCE Mathematical Methods), St Kevin's College, Toorak; VCAA assessor for GAT; former Head of Mathematics, Werribee Secondary College
 Ms Helen Haralambous, Maths Teacher, Williamstown High School, Allason McNamara, Head of Mathematics, Mt Scopus Memorial College, Burwood; Member of the Council of the Australian Association of Mathematics Teachers; and Immediate past President of MAV
 Ms Penny Commons, Project Officer, Chemistry Education Association, University of Melbourne. School of Chemistry, Transition Fellow and Tutor
 Mr Dan O'Keeffe, Australian Institute of Physics (Vic Branch) Education Committee
 Mr Keith Burrows, retired teacher (Carey Grammar School, Woodleigh School and Rudolf Steiner School) and other roles

Victorian Curriculum and Assessment Authority (VCAA)

Dr David Leigh-Lancaster, Maths Curriculum Manager
 Ms Maria James, Sciences Curriculum Manager
 Ms Paula Christophersen, Information Technology Curriculum Manager
 Mr Nick Dobroff, Data Processing Project Manager

Appendix E – Meeting with YMCA Youth Parliament members, 1 October 2013

Participants:

Mr Daniel Stoker
Ms Belinda McEinery
Ms Emma Nicol
Mr Lynton Hurt
Mr Jayden Parsons
Ms Georgie Richards
Ms Felicity-Grace Young

Appendix F – Bibliography

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