SMC&PA Submission 136
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Name: Andrew Findlay
Submission: Personal
Address: [redacted]
Email:
Daytime Phone:

Background:

I have over 21 years of experience teaching both Senior Chemistry and Senior Mathematics within the Qld State School system along with 12 months teaching maths and science in London under the UK's National Curriculum in 1997. While the majority of my teaching experience has been gained in medium to large schools in disadvantaged metropolitan areas, I have also taught in isolated regional communities. I am currently co-ordinating Senior Chemistry at a large academic metropolitan high school where the vast majority of the nearly 200 students enrolled in Chemistry expect to gain a university qualification. I also teach Mathematics A and Mathematics B.

I have considerable experience with the QSA quality control procedures as a district panellist, district panel chair, and state panellist, and have been a marker of the QCS short response sub-test since 1994.

Much of my comment focuses on the science (Chemistry and Physics) syllabuses.

My submission to the committee regarding assessment methods in Chemistry, Physics and Maths:

The way in which maths and science education is delivered, and the nature of the curriculum which underpins that teaching, will always be a contentious issue worthy of serious debate. Teachers, parents, subject area experts and other key stakeholders form a range of views depending on their experience, their perspective, and their familiarity or understanding of the educational process. The stakes are, of course, very high. It is universally accepted that Australia will need greater numbers of well-educated scientists in many specialty areas if we are to maintain our economic status. Globally, there are a myriad of problems requiring solutions that will only be realised through the efforts of highly trained, talented scientists.

The issue of curriculum controversy is certainly not confined to Queensland. The NSW HSC Physics syllabus has attracted plenty of criticism from the tertiary sector as the following quotes from an article written for the Sydney Morning Herald (online) 22nd April, 2005 attest. The article also refers to concern from teachers, parents and students.

"***New syllabuses are geared for students good at remembering, not analytical thought"*** by Professor Joe Wolfe

> John Storey, ***head of physics at the University of NSW***, says that NSW HSC physics is an "interesting subject, but it's not physics".
> Brian James, ***head of physics at Sydney University***, has blamed the same syllabus for giving students "less depth of understanding".
> "The new, softer syllabuses do not serve Australia well. Students who are good at remembering may like them, but what of those students who are really talented at analytical thought? The ones who would easily learn how to take a problem in the world, to translate it into physical parameters, to solve the mathematics, then to take the answer back to the physical world? Engineering, various technologies, physical sciences and, increasingly, biomedical sciences need such students, and Australia needs good engineers and scientists. These students need subjects that will let them discover and use their talents". (Joe Wolfe, Physics Department, University of NSW,2005)

Note: There have been minor revisions to the NSW syllabus since 2005, but it is still essentially the same syllabus. The style of HSC Physics exams is unchanged.

My opinions on the assessment processes used by the QSA are primarily based on my experience in planning, teaching and assessing Chemistry (and Mathematics), and my role as a state panellist. (State panel work involves reviewing a significant number of assessment tasks and student responses from all over Queensland). My conclusions are also influenced by background reading of published research and reports on best practice in science education from around the world. Prior to writing this submission, I watched the initial briefings made by the QSA and Professor Ridd, and read those submissions posted on the committee website up until May 11th.

While I respect their views, and understand that their motivation is for improvement in our system, I have to disagree with Peter Ridd and those calling for a major overhaul of the whole QSA system. Professor Ridd does raise some legitimate concerns, and few would disagree with the notion that there is room for significant improvement with respect to teaching of Chemistry, Physics and Mathematics in Queensland. However the QSA syllabuses are not the ridiculous, unworkable documents that he would have the committee believe, and the assessment methods, if **written in accordance with syllabus guidelines**, allow valid and reliable judgements to be made, and **legitimately** assess the essential skills required to be a scientist.

When the syllabuses are clearly understood, and a course is designed and delivered with appropriate emphasis on inquiry and complexity, the result is a group of students who have been fairly and validly assessed, who have had every opportunity to effectively prepare themselves for tertiary study, and who still value science and maths as fundamentally interesting and an essential part of their education.

I take issue with the following points raised by Professor Ridd (and others):

1. Professor Ridd says (without supporting evidence) that falling participation rates in the subjects in question (particularly Maths C) are due to the introduction of the current QSA syllabuses.

Sheehan and Mosse (Aust. Journal of Teacher Education, Vol. 1 2013) studied declining participation and performance in the senior secondary school subjects Mathematical Methods, Specialist Mathematics, Physics and Chemistry in regional Victoria. They described these subjects as "gatekeepers for high stakes assessment and university entrance", and noted that the downward trend in enrolments in these 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 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". Clearly the QSA syllabuses cannot be held responsible for a problem that exists right around Australia and also in many other developed western nations!

The QSA has already reported that participation in Chemistry, Physics, or Maths has not declined since these syllabuses took effect, and in fact, analysis of the subject data at my school has shown an increase in numbers taking Chemistry since 2008. In 2010, 33.1% of our Year 12 students had at least one semester of Chemistry rising to 36.3% in 2011, and 40.3% in 2012 - the vast majority of these students completing the full four semesters. 2013 has seen the largest intake of Year 11 Chemistry students in many years. To me, it seems clear that the students have very high levels of confidence in the way we are teaching chemistry at this school! Physics and Maths C also are showing no signs of decline, and numbers have risen over the same period. Note: I have included the percentages of senior students to demonstrate that increased participation is not simply a function of increased enrolment!

2. Professor Ridd makes the claim that QSA syllabuses allow students "to do jolly well what they like" as a result of not having mandated content.

The first point that needs to be made here is that each school must write a work program meeting syllabus requirements, and this must be approved through QSA processes. If there is insufficient coverage of the key concepts and ideas, or a lack of rigour or complexity evident in the work program, **it will not be approved**! Once approval is granted however, as with any other system of learning and assessment (QSA, HSC, VCE, IB or other), what happens in the classroom is largely up to the competency, professionalism and effectiveness of the individual teacher; however, as with other educational jurisdictions, there are also degrees of oversight from students, parents, fellow teachers, school administration, and curriculum authorities.

Secondly, I cannot accept the contention that school Chemistry and Physics should be treated purely as a finite set of known facts and principles. Authentic science is about challenging accepted knowledge, asking questions about the world around us, and discovering new information. I think that Joe Wolfe is absolutely right to be concerned about a content-driven syllabus, and it is worth noting that the "analytical thought" he calls for is a significant component of the QSA syllabuses. A 2011 report to UNESCO ("Current Challenges in Basic Science Education ") included the following recommendations for modern science education: "The first is a curriculum based on science as a process rather than a product, with the focus on deeper learning. The second factor is adequate and appropriate teacher education, as basic education crucially depends on the person who brings about the curriculum" and "thirdly… international investigations and specialists all point to the value of Inquiry Based Learning".

If we are to succeed in educating our scientists effectively, we must value and foster the habits and skills that made the great scientists "great" and not simply concentrate on a pure knowledge base.

3. Professor Ridd holds the current QSA Chemistry/Physics/Mathematics syllabuses responsible for less than capable 1st year (engineering) students

The maths and science teaching staff I work with are acutely aware of the need to effectively prepare our students for tertiary study. The idea that a former student of ours might not succeed at university because of inadequate preparation is completely unacceptable to us. However, aside from a comprehensive career counselling program at school, the nature of tertiary entrance procedures denies us any influence regarding a university's decision to enrol a student in an inappropriate scientific discipline.

That said (and based on anecdotal evidence only), students I have spoken to after the completion of their first year of university in scientific and engineering disciplines report that their school science and maths education prepared them extremely well for tertiary study. High grades in university subjects appear to validate this. More concrete evidence is available in the form of the results obtained by students completing university chemistry subjects whilst at school – these results have been quite exceptional!

4. Professor Ridd contends that grades arrived at using written standards and criteria sheets are "just a guess really", and that adding marks should be mandatory in order to arrive at a result.

When assessment tasks are written to the criteria, valid decisions about student achievement are relatively easy to make, and the criteria provide direct and specific feedback to the student about their strengths and weaknesses. Speaking as a parent, I would much rather be given information highlighting the actual deficiencies in achievement rather than an unhelpful percentage. A marked written criteria sheet enables students to focus their attention on problem areas either through their own efforts, or with help from the teacher or tutor. A simple percentage or numerical mark can never achieve this, is heavily dependent on the complexity of the task and no real indicator of what students can or can't do.

I submit that I can speak with some authority on the subject of valid and reliable judgements using written criteria, as I work as part of a 4-person teaching team that is required to assess up to 120 responses at a time. Although calibration is required, and difficult decisions sometimes need to be made at the margins, marking is rarely questioned by students or parents, and when it is, the link between the evidence and the standard is quite clear. Careful analysis of data shows that our Chemistry results correlate very highly with other measures of student ability – results in other subjects, ACER Test results, QCS results (practice and actual), and OP score – and it is quite evident to me that in <u>no</u> way are they based on "guesswork".

5. Another complaint is that Extended Experimental Investigations (EEIs) are far too lengthy, take too much time, and cause too much student stress.

The examples used by Professor Ridd to illustrate his concerns about EEI reports bear no resemblance to syllabus requirements and based on my experience, are simply not representative of what students are doing. Neither can I accept that any competent teacher would ever say "just write as many words as you can".

My experience is that when the investigation follows specific teaching of a related set of concepts, and students are equipped with the appropriate skill set, the result is a much deeper, more rounded understanding of the chemistry involved.

EEI tasks have not contributed to undue levels of stress amongst the students I teach; in fact, many find examinations more stressful. I accept that stress to students could be a reality when they have several EEI tasks due at the same time, especially if this coincides with a school examination period. However, schools do have the capacity and the responsibility to ensure that this does not happen. In my situation, Chemistry EEI reports are due in mid-term to avoid exam time, and are completed in different terms to Physics and Biology. Any stress that does occur is generally due to poor task management.

I completely support the use of Extended Experimental Investigations in Senior Chemistry as an effective use of time for student learning and assessment. A UNESCO report (Jan 2011) stated "Assessments which support learning should be prioritised above other assessments" i.e. those that simply measure achievement. EEIs allow students to engage in chemistry in interesting and authentic ways, to participate in the scientific process, and to "do what scientists typically do" rather than simply memorise facts and processes. The tasks really do encourage students to develop and demonstrate critical thinking skills such as synthesising, hypothesising, interpreting, generalising and evaluating – the very things we want in our scientists. As one parent said to me just recently when asked about how their high-achieving student felt about EEI tasks, "She loves them because it gives her a chance to explore her own ideas".

<u>Summary:</u>

The QSA Senior Science syllabuses ensure that teachers focus on the skill set required by modern scientists, expects that tasks used support the development of these skills, and demands that the achievements reported on are based specifically on what students can or can't do. Of course there are improvements that can be made, but on the basis of the evidence I have seen, I can only conclude that these syllabuses are a step in the right direction.

Before reaching any decision, I would hope that the committee consider the following points which I believe have a much greater influence on the success of Chemistry, Physics and Mathematics education than either the syllabus or assessment methods:

- It is unreasonable to expect that all teachers of Chemistry, Physics, and Senior Mathematics will be able to deliver the outcomes required by the syllabuses (including appropriate assessment) **without effective, useful professional development.**
- It is my understanding that it is quite common for Chemistry, Physics, and Senior Mathematics classes to be taught by teachers who have not completed tertiary qualifications in that area. Can we reasonably expect students to be effectively prepared if the teachers themselves have not experienced what is necessary to succeed in that subject?
- It is becoming increasingly difficult finding quality Secondary Science and Mathematics teachers to fill positions. Unless we can attract sufficient numbers of quality graduates with both the requisite knowledge and the capacity to deal with the demands of the profession, our ability to produce scientists will continue to ebb away.