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Queensland's Science Curriculum: Still Learning from the Past

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Introduction

In *The Future Curriculum for School Science: What Can Be Learnt from the Past?*, Peter Fensham (2016) described a number of science curriculum reforms and attempted reforms. Under the heading "Precedents for Future Directions", he discussed the State of Queensland, Australia, which had been able to implement a "radical new direction for science education in the final two years of schooling" (Fensham, 2016, p. 174). While this was true, eventually, this curriculum reform resulted in a contestation that led to a parliamentary inquiry and was antecedent to (if not a direct cause of) a significant change to Queensland's senior assessment system. This article provides a commentary about the challenge of science curriculum reform using an historical and partial insider account of Queensland's senior physics curriculum. A key part of this includes a direct review of the physics syllabuses from 1977 through to 2007. This commentary is greatly informed by Peter Fensham's insights about the politics of science curriculum reform; a number of research reports and papers about Queensland's science curriculum over this period; and my own experiences as a physics teacher in Queensland and then as an officer working at the government authority responsible for the curriculum.

Queensland's Freedom for Authentic Assessment in High-Stakes Contexts

Queensland is one of the few educational jurisdictions in the world with a significant history (from 1973 to 2019) of 100% school-based assessment in senior secondary schooling, unlike the majority of other national and international schooling systems that have some form of external assessment of senior subjects (McCurry, 2013). Prior to 1973, Queensland had a public examination system, with examinations written and controlled by the University of Queensland. In the 1960s, it became clear that this system was not able to cope with the increasingly larger and more diverse cohort of senior students. The physics examination results reflected this, with 68% of students failing the exam in 1967 (Queensland Curriculum and Assessment Authority, 2014). Results like this led to public criticism and an inquiry (Clarke, 1987). The

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inquiry recommended that school-based assessment replaces public examinations (Radford, 1970) and the last public exam was held in 1972 (Logan & Clarke, 1984).

In his reflection, Fensham (2016, p. 174) referred to the Queensland school-based assessment system as "freedom for authentic assessment in high stakes contexts". This system began in 1973 and at the time represented an unprecedented and major shift in assessment practices (Sadler, 1992). Assessment was no longer centrally controlled with a final examination. It now belonged to teachers, schools and review panels. The 1980s introduced further changes, from norm-referenced to standards-based assessment (Sadler, 1986). With 100% school-based and standards-based assessment, teachers had to focus on developing assessments that aligned with the concepts and skills being taught and that suited their school context (Wyatt-Smith & Colbert, 2014). A description of this system of curriculum and assessment within the context of senior physics and how it evolved into a contestation comparable to Fensham's (2016) account of curriculum reforms is the subject of this commentary.

The Evolution of Queensland's Physics Syllabuses

Alongside the significant changes in Queensland's assessment practices were broad international and national trends in science education, which as we will see also had an influence on Queensland's senior science curriculum. Fensham's (2016) insightful account of these trends included a model, developed in conjunction with David Layton (Fensham, 1988), which proposed considering the relative weight of influence of six competing societal demands on school science education for determining its character. These demands — "political", "economic", "subject maintenance", "cultural", "social" and "individual" — were grouped into two categories as outlined in Table 1.

In this model, the upper societal demands compete with the lower. In 1988, this was described by Fensham as a dilemma — is the purpose of school science education to serve the upper demands and reproduce the subject to develop the next generation of scientists and engineers? or is it to serve the lower demands and develop a more humanistic school science experience that asks students to consider the role of science in society and to learn science for their own interest? Furthermore, by meeting some of these demands, does this necessitate that others cannot be met? such that we have "curriculum competition" between "the two distinct targets of a scientifically-based work force and a more scientifically literate citizenry" (Fensham, 1988 p. 7). In outlining this now decades-old tension, Fensham (2016) also discussed Roberts' (2007) two visions for scientific literacy, which distinguish

Table 1 The two categories of competing societal demands on science education (Fensham, 1988)

Upper demands • Political • Economic • Subject maintenance	"Political" relates to filtering a relatively small number of students into high status professions; "economic" relates to ensuring scientific and technical expertise of these individuals to sustain and drive the economy; and "subject maintenance" relates to reproducing science as defined at the tertiary education level in order to maintain the elitism of the field
Lower demands • Cultural • Social • Individual	"Cultural" and "social" relate to the ways that cultures and social life are influenced by science and provide people with a sense of control over the application of science; and "individual" relates to the intrinsic interest, inventiveness and potential for growth and satisfaction that can come from learning science

between teaching science through a disciplinary axiom (aligned to the upper demands) and teaching science through real-world contexts (aligned to the lower demands).

The 1977, 1987, 1995, 2001 (Trial-Pilot), 2004 (Extended Trial-Pilot) and 2007 Queensland physics syllabuses were reviewed with this distinction in mind. These syllabuses were selected as they are representative of the curriculum frameworks developed in the school-based assessment period. Although from 1973 there was no longer an external examination, most schools still used the previous more prescriptive syllabuses while the Board was developing and trialling new syllabuses that were designed for school-based assessment (Logan & Clark, 1984).

Drawing upon Fensham's categories of competing societal demands and Roberts' two visions for scientific literacy, we can frame two positions for the series of Queensland physics syllabuses over the school-based assessment period:

1. 1977, 1987 and 1995 syllabuses: prioritising the upper (political, economic and subject maintenance) demands, resulting in a *traditional-discipline-topic* curriculum that looked "inward at the canon of orthodox natural science, that is, the products and processes of science itself" (Roberts, 2007, p. 730).
2. 2001, 2004 and 2007 syllabuses: prioritising the lower (cultural, social and individual) demands, resulting in a *Science Technology and Society (STS)-context-inquiry* curriculum that "derives its meaning from the character of situations with a scientific component, situations that students are likely to encounter as citizens" (Roberts, 2007, p. 730).

The envisioned, developed and assessed curriculum of these two groups of syllabuses is discussed in relation to these two positions, to bring to light the impact of the "radical new direction" on teaching, learning and assessment, which ultimately led to the contestation to which Fensham (2016) alluded.

1977, 1987 and 1995 Syllabuses: Prioritising the Upper Demands

The envisioned curriculum of the Queensland physics syllabuses through the school-based assessment period is most clearly seen in their introductory sections: "A view of science" and the subject specific rationale. These sections provide insights into the curriculum's position on the nature and purpose of science; the role of science and science education in society; and the humanistic benefits of studying the subject. In other words, they were explicit in their vision for school science, and over the various iterations, they can be viewed as reflections of the scientific and educational zeitgeist.

From the 1977 syllabus (*Syllabus in Science Years 8–12*) through to the 1995 syllabus (*Physics Senior Syllabus*), the envisioned curriculum described a vision of science as a human endeavour, a fluid body of knowledge, a mode of enquiry and a philosophical and social force. The 1995 syllabus was explicit in identifying the importance of STS, stating:

> Science has profound worldwide impact — economic, environmental, ethical, political, social and technological. An understanding of scientific perspectives can enhance participation by citizens in deciding on, and responding to, the directions of science and technology. Social awareness within the scientific community and scientific literacy in the general community are essential for human survival and economic development. (Queensland Board of Senior Secondary School Studies 1995, p. 1)

Thus, the lower demands seemed to have been prioritised. However, as Fensham (2009, p. 1079) argued, it was often the case that the lower demands were only really given a place in the introductory sections “as some sort of consolation prize”. The 1977, 1987 and 1995 syllabuses conformed to this observation.

The developed curriculum in Queensland in this period refers to the subject matter (the specific content and its organisation); the requirements of a school’s work program (the way in which the syllabus directed a school to teach the subject matter); and any guidance provided about practical work and teaching and learning. The 1977, 1987 and 1995 syllabuses organised subject matter into discipline-based topics such as “physical quantities and measurement”, “wave motion”, “electricity and electronics” and “atomic and nuclear physics”, with the 1987 and 1995 syllabuses providing more detail by specifying a minimum depth of treatment and ideas for extension (Queensland Board of Secondary School Studies, 1977, 1987; Queensland Board of Senior Secondary School Studies, 1995).

While content was highly specified in these syllabuses, assessment specifications and conditions were not outlined, a feature of Queensland’s school-based assessment through this period. The 1987 and 1995 physics syllabuses provided non-exhaustive lists of possible assessment techniques such as “tests”, “lab reports”, “practical tests”, “skills checklists”, “library research” and “oral presentations”, without any associated description, specifications or conditions (Queensland Board of Secondary School Studies, 1987; Queensland Board of Senior Secondary School Studies, 1995).

Thus, despite the rhetoric outlined in the first few pages, this group of syllabuses was unequivocally *traditional-discipline-topic* science curriculum. While the envisioned curriculum focused on the cultural, social and individual benefits of studying science and physics, the developed and assessed curriculum, what teachers actually do in the classroom, conformed to the disciplinary axiom and transmissive pedagogy that Fensham (2016) outlined with a number of other examples. As we will see, the disconnect between the stated envisioned curriculum and the reality of the developed and assessed curriculum of these syllabuses did not go unnoticed.

2001, 2004 and 2007 Syllabuses: a “Radical New Direction” Prioritising the Lower Demands

In the early 1990s, in response to the need “to provide an appropriate science education for a wider audience of students as well as cater for the traditional tertiary-bound group”, the Queensland Board of Secondary School Studies commissioned the Senior Sciences Future Directions project (Beasley et al., 1993, p. 2). The emerging issues raised in the resulting report were to consider designing syllabuses for all students (taking into account broader post-schooling pathways), reduce compulsory content, include more contemporary and Australian science, develop and explain assessment, integrate STS, ensure lab and field work and ensure the explicit incorporation of thinking skills within learning contexts (Beasley et al., 1993). The report to the Board outlined the external pressures that were being applied to science education and thus laid the foundations for a significant change to the senior secondary science curriculum in Queensland.

This change was set in motion in 2001 with a trial syllabus that was piloted by a small number of schools (Beasley & Butler, 2002). The envisioned curriculum of the 2001, 2004 and 2007 syllabuses (respectively: *Physics Trial-Pilot Senior Syllabus*, *Physics Extended Trial-Pilot Syllabus* and *Physics Senior Syllabus*) continued to emphasise the same STS themes as the preceding syllabuses (Queensland Board of Senior Secondary School

Studies, 2001; Queensland Studies Authority, 2004, 2007). The significant difference was in the arrangement of subject matter and the assessment, which was now aligned to the envisioned curriculum. Instead of specific subject matter descriptions organised in discipline-based topics, physics syllabuses from 2001 onwards outlined the "key concepts" of the discipline and their associated "key ideas" grouped by the themes/organisers "Forces", "Energy" and "Motion". The purpose of this taxonomy was for teachers to develop context-based units (for example, "amusement parks", or "music and audio production") in which the key concepts and ideas were to be developed and revisited over the course (Queensland Board of Senior Secondary School Studies, 2001; Queensland Studies Authority, 2004, 2007). The cultural and social influences were now at the centre of teaching and learning.

Changes to assessment requirements were equally significant. From 2001 onwards, the number of assessment techniques was reduced and included an "Extended Experimental Investigation" (EEI) that could last for 4 weeks or an entire unit, and a written report/assignment that focused on a (primarily) non-experimental physics question or issue. The standards that teachers used to grade student responses matched this change. In the 1995 syllabus, students were only required to undertake "simple scientific process tasks … devising and designing simple or single-step investigations" (Queensland Board of Senior Secondary School Studies, 1995, p. 35). From 2001 onwards, the standards were explicit in the requirement for students to develop and answer their own research questions, as exemplified in the 2007 syllabus with "formulation of justified significant questions/hypotheses which inform effective and efficient design, refinement and management of investigations" (Queensland Studies Authority, 2007, p. 30).

Teachers were to provide scaffolding for these tasks, but not in the form of a series of steps or by specifying the physics (Queensland Studies Authority, 2010). With students given more autonomy in deciding how to undertake their inquiries, as opposed to participating in a "recipe style" investigation aimed at verifying a phenomenon (Staer et al., 1998), the "individual" was now at the centre of assessment.

As was noted at the time, this represented the beginning of a significant departure for secondary science teaching in Queensland, a paradigm shift that required a "180-degree change in teacher and student behaviour … for the syllabus to be implemented in the spirit to which it is intended" (Beasley & Butler, 2002, p. 4). The trial pilot syllabus evaluation report commissioned by the curriculum authority concluded that the new physics syllabus had resulted in significant changes in teaching and assessment. Teachers believed their students had less extensive knowledge of physics, but a deeper understanding of key concepts and principles, and had developed higher levels of investigative skills and were using higher order thinking skills more readily than previous cohorts; and the majority of students were enthusiastic about the new style of course (Lucas, 2004). The syllabus was revised and then opened up to more schools to participate in an extended trial pilot, before a final revision to the general implementation syllabus, published in 2007 and implemented over a 2-year period from 2008. With the full implementation of the *STS-context-inquiry* syllabus by 2010, the goals initiated with the Senior Sciences Future Directions project had seemingly been met.

The "Radical New Direction" Is Contested

An important point to consider when reflecting on the challenge of this reform was that over the period from 2002 through to 2009, most teachers were still using the 1995 *traditional-discipline-topic* syllabus. From 2003 to 2005, only 12% of Year 12 physics students studied the *STS-context-inquiry* course. Over 2006–2008, this rose to 33%. It was only when schools were required to implement the 2007 syllabus that the majority of Year 12 students completed the *STS-context-inquiry* course (51% in 2009 and 100% in 2010) (Queensland Curriculum and Assessment Authority, n.d.). The interim syllabus evaluation report by Lucas (2003) touched on this, pointing out that, given that schools and teachers were self-selected, the trial may not have been representative of all Queensland physics teachers. The teachers involved in the early trial were extremely well-qualified and experienced, with many becoming teachers after prior careers such as scientists and engineers. When faced with developing a context-based science course, their previous experiences would likely have been beneficial. Nevertheless, they required and were provided with significant support (Lucas, 2004).

Beasley and Butler (2002) reported on the challenges facing teachers and students in implementing these syllabuses. They observed that the focus of professional development provided by the Board was on procedural aspects of implementation (developing work programs and using the standards to make judgments about student achievement on their assessment). They went on to point out that:

> Teachers need professional development activities that focus on their beliefs, on their values and on their assumptions about the vision for the senior subjects. If the culture of the senior science subjects does not radically change, this new syllabus is doomed. (Beasley & Butler, 2002, p. 32)

In effect, the Queensland physics syllabuses from 2001 onwards were policy documents designed to change science education practice in Queensland by changing the "rules". Reforms such as this, mandated through changes in curriculum, are commonly experienced as an external imposition on teachers in that they had no choice but to adopt the reform (Ryder, 2015). This was the case with the 2007 syllabus for general implementation, which was mandatory for all physics teachers to teach. Such external impositions are open to contestation.

In 2001, an email discussion list was set up to support teachers implementing the trial pilot. Teachers used (and still use) this forum to share resources and discuss all aspects of physics teaching and learning, including various issues about the syllabus(es) and assessment. Initially, the discussion list membership was predominantly made up of the self-selected group of teachers involved in the trials and emails to the list mainly focused on interpretations of the syllabus and sharing resources. As a physics teacher and then officer for the curriculum authority, I was a member of this list from 2008. I was able to directly witness the changing nature of some of the topics discussed by list subscribers. While still predominantly focused on sharing resources, the discussion list also became a forum for some participants to voice their dissatisfaction with aspects of the *STS-context-inquiry* syllabus. In October 2009, a university physicist emailed the list to organise a face-to-face meeting with teachers to discuss these issues. The issues raised at the meeting were shared with the list and were a frequent subject of conversation over this period. Eventually, this evolved into a movement for change beyond the discussion list, with a website and media coverage, resulting in a parliamentary inquiry in 2013 (as noted in Fensham, 2016).

The inquiry received 288 submissions and held a number of public hearings (one of which I attended as a witness) and an expert advisory forum (that Peter Fensham attended, as did the aforementioned university physicist) (Education and Innovation Committee, Parliament of Queensland, 2013). A key issue identified in the final report related to opposing views about approaches to assessment in senior mathematics, chemistry and physics, for example, that the assessment techniques did not adequately assess the factual and procedural knowledge and skills of the discipline(s), referred to in the report as "the basics". It also investigated other issues raised by stakeholders, including mathematics, chemistry and physics enrolments, and the academic performance of Queensland students (Education and Innovation Committee, Parliament of Queensland, 2013).

In considering such contestations, Fensham (2016) argued the model of competing societal demands was deficient as a predictive model, as it did not take into account the authority of those responsible for enacting it. While his model may not be thoroughly predictive, Fensham's (2016) account of curriculum contestations, to which I now add my own, suggests it offers a great deal of explanatory power. Specifically, the societal pressures in the model are not "things" out there on their own. They manifest themselves through the habitus of the people that are in a position to have authority over school science. With this in mind, Fensham's (2009) observation about the locus of authority for science education was particularly astute. Education researchers were often focused on the "cultural", "social" and "individual" demands, which were usually only found in the front matter of curriculum documents. In contrast, the "political", "economic" and "subject maintenance" demands tended to be supported by academic scientists and conservative science teachers, and this is what determined the content and assessment (Fensham, 1993, 2009).

The Present and the Future?

In July 2013, the Australian Council for Educational Research (ACER) was tasked to review Queensland's senior assessment and tertiary entrance systems, including taking into account the findings of the parliamentary inquiry. The final report, published in October 2014, included a recommendation to introduce external assessment for senior subjects worth 50% of a student's result, which was also a recommendation from the parliamentary inquiry (Matters & Masters, 2014). Thus, despite the claim from some researchers only a few years earlier that "there is essentially no public or professional desire for a return to the old ways … any attempt to return to external examinations would be difficult, even traumatic, and widely considered as retrograde and destructive" (Maxwell & Cumming, 2011, p. 187), the return to some form of external assessment was welcomed. External assessment was seen as a mechanism to ensure students finished high school with common content knowledge, and given it was externally developed and marked, it would increase public confidence in the system and make comparing results more valid (Matters & Masters, 2014). In 2015, the Queensland Curriculum and Assessment Authority surveyed nearly 4500 teachers, with over 70% endorsing the introduction of external assessment as a complement to school-based assessment (Queensland Curriculum and Assessment Authority, 2015). Following further input from key stakeholders, a new senior assessment and tertiary entrance system began with Year 11 in 2019. In 2020, Year 12s studying subjects that are designed to lead to further study at university sat external examinations for the first time since 1972. The era of 100% school-based assessment in a high-stakes context came to an end.

Throughout his 2016 paper, Fensham referred to a number of attempted curriculum reforms as "failures". Given that Queensland had a parliamentary inquiry about the "radical new direction" of senior physics (and chemistry and mathematics), which recommended the introduction of an external examination for the first time in 40 years, one might consider casting the 2007 syllabus into the "failure" category as well. However, Fensham (2016) also concluded his reflections with five assertions about the possible future of mainstream science curriculum that resounded with me. Of particular relevance to this commentary and the current Queensland senior science syllabuses are assertions 1 and 4:

1. Educational authorities should be encouraged to link authentic assessment to teaching and learning, which is both good pedagogical practice but also supports the reality of increasing public accountably in education (Fensham 2016, p. 181).
2. With the development of the Australian Curriculum: Science, there was an argument for treating the secondary years (7 to 12) separately from the primary years, where it might have been possible to challenge the stronghold of the "disciplinary axiom" (Fensham 2016, p. 182).

In Queensland, the 2019 physics syllabus no longer requires teachers to develop contextualised courses of study, with subject matter back to a more "traditional" organisation (assertion 4). This is a function of the Queensland Curriculum and Assessment Authority's legislated requirement to adopt the senior secondary Australian Curriculum (which is organised this way) and the new accountabilities of senior secondary assessment that include an external examination at the end of Year 12 (assertions 1 and 4). While contextualised courses of study are no longer a feature, the 2019 syllabus does still require teachers to develop summative school-based (now called "internal") assessments that are similar to their predecessors but are more clearly defined and explicitly linked to teaching and learning (assertion 1). Accounting for 40% of the final grade, the "Student Experiment" and "Research Investigation" require students to develop a research question and undertake a scientific investigation to answer it (Queensland Curriculum and Assessment Authority, 2019). With the return of discipline-focused topics, Queensland's direction is now not so "radical". Nevertheless, the 2007 syllabus has a significant positive legacy in that, as with the 2007 syllabus, the mandatory aspects of the 2019 syllabus ensure that students are engaged in open-ended and authentic scientific inquiry (Queensland Curriculum and Assessment Authority, 2019).

Conclusion

Fensham's (1988) model — considering the relative weight of influence of the two competing groups of societal demands on school science education — continues to provide a useful way of conceptualising the different views about the purposes of studying science at school. The thinking that underpinned the 2019 suite of senior science syllabuses in Queensland was partially premised on the idea that "science education serves two purposes — feeding human capital into STEM related careers and jobs in the economy and developing scientifically literate citizens as a part of a broad liberal education" (Queensland Curriculum and Assessment Authority, 2016, p. 11). Beyond this, the development of the 2019 syllabuses involved a considerable number of other complexities, such as the political reality of the increasing public accountability facing educational bureaucracies. Here again is an area that Peter Fensham's writings offer considerable insight, such as his reflections on his involvement in developing the Australian Curriculum: Science, where the contributions he and other expert advisors made were filtered through curriculum managers, such that they were "banally reduced to mere advice" (Fensham, 2013, p. 166).

Fensham (2009, 2016) argued (and I concur) that science education researchers should have significant input into the science curriculum. However, to be effective, researchers need to have a clear understanding of the politics that surround curriculum advocacy and development. Fensham challenged researchers to understand that science education is not isolated from culture and politics, but is deeply affected by the values and authority of those in a position to impact policy (Fensham, 2013). I have witnessed this and have been involved in the types of significant curriculum change (and attempted change) that Fensham documented throughout his career.

Peter Fensham's (2016) sage words resonated with me in that by "learning from the past" we can become "sponsors for future directions". He also argued that the politics, policy and practice of science education were important areas that lacked research (Fensham, 2009). It is hoped this commentary goes some way to redressing this gap by adding to Fensham's accounts of the challenges of science curriculum reform.

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Declarations

Competing Interests I am currently the Director, Senior Curriculum and Assessment at the Queensland Curriculum and Assessment Authority. In this role, I lead the development of senior syllabuses and external assessment. During the development of the 2019 Physics syllabus, I was the Learning Area Manager, Mathematics.

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