A NATIONALCURRICULUM: COMPETITION, ADVANCES AND RETREATS

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Abstract

This paper is an outcome of a study on National Science Curriculum (NSC) in Australia. This paper centres around the experts' views on the scenarios of future science curriculum. The data were gathered through interviews with five leaders from different Australian states. The data were analysed following the process of qualitative data analysis outlined by McMillan and Schumacher (2006) involving selecting text extracts, identifying patterns, themes and key concepts, coding and categorisation, code testing against interpretation and constant comparison. The analysis is further checked by a research assistant. It will be shown that experts agree on the strengths and weaknesses of the curriculum. The results show that there are two very different scenarios that seem possible. One emphasises state independence, standardisation, compliance and control. The other emphasises trust in teacher professionalism and knowledge exchange.

Key words: National Science Curriculum, scenarios of future science curriculum

Introduction

As a child of the 1950s I've learnt and taught science as well as lecturing and researching in science education through a period punctuated by significant perturbations in curriculum. All have been well intentioned. Yet, it seems axiomatic that curriculum change in itself cannot cure whatever it is that ails school science. Nevertheless, hope springs eternal. This paper considers the extent to which these hopes are well placed, first through a brief and necessarily selective consideration of the historical context of science curriculum development and then through an analysis of the views of experts.

Successive science curriculum developments, once led by the USA, were driven by national doubts about scientific superiority, motivated by economic and military concerns (Lieberman, 1982). Post-Sputnik curricula began with the Physical Sciences Study Committee Project (PSSC) in 1957 and a scientific habits movement that emphasised the teaching of process skills, initiated by the American Association for the Advancement of Science (AAAS) in 1961 (*Science a Process Approach)*. Proposed reforms that emphasised access to science for all included *Science Technology, and Society* (Bybee, 1986) and *Science for all*

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Americans, (AAAS, 1989). More recently, scientific literacy (OECD, 2006) has become an entrenched, almost universally accepted goal of science education. These trends were perhaps most prevalent in the USA but their impact was felt throughout the English speaking world (Goodrum, Hackling & Rennie 2001).

From the 1970s to the early 1990s there were major shifts in thinking about science learning and teaching. Practical teaching approaches were generated to make connections between learning as a construction and classroom learning and teaching practice (Bidulph & Osborne, 1984). Research on children's science and constructivist views of learning provided the impetus for new curriculum goals that take into account learners' cognitive frameworks (Osborne & Freyberg, 1985; White, 1991). Consistent with the shift from behaviourism and Piagetian stages of development to generative views of learning, curricula responded – somewhat. The construction of personal and science knowledge were evident in Australia (Curriculum Corporation, 1994), in the UK National Curriculum (Millar & Osborne, 1998) and in the USA (AAAS, 1989; Rutherford & Ahlgren, 1990). Scientific habits no longer dominated. They were retained however, as sections of curricula, such as 'working scientifically' in *Science - A Curriculum Profile for Australian Schools* (Curriculum Corporation, 1994) and teaching 'scientific habits of mind' in *Science for all Americans* (AAAS, 1989; Rutherford & Ahlgren, 1990). Interestingly, and despite growing evidence that children learn science through psychological order rather than through a predetermined logical order (Driver, 1981), the notion that student learning is best organsied according to immutable stages continued to be reflected by strict logical sequencing of learning in many curricula.

The trends briefly identified so far have been played out in a series of curriculum developments both locally and overseas. It is reasonable to ask how the most recent National Science Curriculum (NSC, National Curriculum Board, 2009) builds on these and whether dated fashions have been entirely jettisoned. Building on this history, there are recent points of emphasis in Australian science education that have become prevalent in the lead up to and during the 21st century which are evident in the National Curriculum Shaping Paper: Science and the curriculum itself (National Curriculum Board, 2009) - a detailed discussion of these is provided in Goodrum *et al. (*2001); and Tytler (2007).

A positioning of science as critical to international competiveness, though less strident than that of the 1950s, is evident in literature that has influenced recent (political) thinking about school science (Batterham, 2000). In crude terms, Australia requires a clever, scientifically capable workforce, and school science must change to serve this purpose (among others) and ensure supply. This is reflected in reports in

Australia (Goodrum *et al,* 2001; that were instrumental to the NSC.

Demand for internal competitiveness derived from science capability, however, has not led to a re-emergence of the science-profession-oriented curricula of past. Rather, an emphasis on science interest and engagement has arisen from evidence of a lack of student interest and lower participation rates (Baterham, 2000; Goodrum *et al,* 2001;). In the past, it was as if the science was regarded as intrinsically useful, good and interesting. Now it is clear that school and university science have been allowed to become out of kilter with the interests of the modern student population and perhaps of society as a whole (Tytler, 2007). Re-engaging our community with science has become the new mantra.

Engagement as a primary outcome of schools' science experience has resulted in a case for a new and different curriculum (Goodrum *et al.* 2001). The aim has been to create an attractive curriculum emphasising science inquiry (student investigations, contextualised and relevant science experiences, generating and testing ideas), as well as a raft of changes to pedagogy, school science environments, teacher preparation and professional learning that are not readily addressed by a curriculum. Tytler (2007) too provided a set of challenging recommendations for change. *Re-imagining Science Education* is too extensive a work to summarise here but he extended the arguments of Goodrum *et al.* (2001). Among other things, Tytler employed socio-cultural theory to understand the status and nature of school science and critiqued recent emphases that had arisen from conceptual change theory. He supported general positions taken by Goodrum *et al*. (2001), stressing the need to exploit and create dispositions towards science and scientific dispositions; to feature creativity and exhilaration in science learning; and to avoid rigid prescription. Generating and sustaining interest in science was seen as critical to long-term engagement. This is consistent with a socio-cultural view of interest. In a social-cultural model (Hidi & Renninger, 2006), interest progresses though phases, which may wax, wane and reverse. It is therefore interesting that the organization of NSC content seems more consistent with Piagetian stages and logical order of learning than socio-culturally inspired phases of interest or reflect a psychological, socially constructed order of science learning

This introduction can only provide a brief and incomplete analysis of relevant changes in the context of science curriculum development. More comprehensive reviews relevant to the NSC are available elsewhere (e.g., Goodrum *et al*., 2001; Tyler, 2007).

Method

In this broad context, this paper explores science education research experts' perceptions of the NSC agenda. In developing the argument for this paper, views of leaders in the field of Science Education in Australia were sought. Five leaders from different Australian states were interviewed to ascertain their perspectives.

The interviews were conversational and participants were advised of the interview protocol in advance. Interviews were recorded and transcribed. Analysis of the transcripts followed the qualitative process outlined by McMillan and Schumacher (2006): selecting text extracts, identifying patterns, themes and key concepts, coding and categorisation, code testing against interpretation and constant comparison. The analysis was checked by a research assistant. Variations in interpretation were resolved in discussion. A draft of the leaders views regarding the NSC was provided to the leaders for checking. In reporting, some small modifications to transcripts were made and references that were mentioned in interviews were inserted. As there was much agreement in the views expressed, the views have often been combined in this paper as an amalgamated character (Geelan, 2003). This editing and amalgamation of data was completed before the results were provided to participants for comment. Some minor editing for clarity has occurred in response to suggestions from reviewers and the editor.

Result and Discussion

Population and workforce mobility

One of the principal arguments for a NSC identified by all experts, was political leaders' desire to address perceived educational disadvantage arising for students who move across state borders. Perceptions of educational disadvantage, creates a disincentive for families to exploit opportunities for employment and exacerbates skill shortages.

> *Mobility of workforce is a social and political, in first instance, for various reasons. Hence, the curriculum is built around kids who cross state borders and have to repeat topics. It's awkward for them if the curriculum is not lined up.*

The experts doubted the validity of the argument as applied to science learning, which may not be linear. The assertion was viewed as broad political positioning rather than sound educational argument.

Making the most of limited resources

Good science curriculum design requires extensive resources and expertise. The universal view was that a national curriculum provides an opportunity to create a curriculum of higher quality than that which could be developed by each state or territory simply because the resources available for curriculum development are greater. The argument is that writing curriculum requires significant resources and we cannot spend those resources six or seven times. And the science curriculum in different states and territories is not that different anyway (Dawson & Venville, 2006). *So, why not go to a national one*?

The perceived problem for curriculum production was strongest for smaller states and territories. The national curriculum development process provides greater resource, access to greater collective expertise and wisdom. As well, the opportunity to build on varied experiences with science curriculum across many states and territories could generate a fundamentally better curriculum.

There has been better consultation and more resources put into developing the curriculum, getting different people's opinions on it. Working through all those processes and being a national document has a lot more strength, I think, than just a state document.

The view was also put that the critical advance, made possible through a NSC, was not primarily in the construction of a 'better' curriculum per se, but rather in its implementation.

Having a national approach can be unifying and can help the country to put a lot more resources into developing appropriate professional development and resources that will support the teaching and learning of science.

The argument is that if a science curriculum is developed nationally, the resources of states and territories need not be devoted to curriculum design but can be used to support implementation, to enhance science teaching and learning. Furthermore, if the states and territories share the same curriculum, resources, workshops, professional development programs and research findings that are generated should be broadly applicable across Australia.

Quality control

The development of a NSC is viewed as quality control: if the education of Australians is to be improved then educational outcomes need to be monitored. The quality of teaching may be difficult to determine. A naïve view, however, is that the quality of teaching can be assessed indirectly by examining students' test results. A common NSC for all students would make such testing and comparison more feasible. Thus, a NSC enables monitoring and control of science teaching and learning:

The national agenda is to standardise. There is a whole compliance culture that develops around government generally, and certainly the current federal government. International testing has caused a lot of concern - and science is part of that package. A lot of it is driven by compliance. That everyone should do this at this year level. Then we know what is happening and then we've got control over teachers and schools.

Although the experts outline the argument succinctly as an influence on the design and development of the national curriculum, none see this as beneficial. Rather, the counter argument is presented that standardisation, testing and monitoring may detrimental to science education.

There will be a tendency to have everyone doing the same content at the same time across the nation. Now if that somehow is privileged in some form of formal testing it will make science the worst it has been for fifty years. ... Despite what the planning documents might have indicated, it will remove the opportunity for local schools to *develop something of relevance to them, because they will have to comply. So context will play a very small part in the implementation, even though context is deliberately mentioned as an important starting point.*

With regard to the general influences on the national science curriculum, the experts supported the arguments that a national curriculum had potential

1. to ensure effective uses of resource supporting science education; and
2. to improve dissemination of good science education ideas and practices.

In contrast, the experts questioned the soundness of the arguments that

1. a NSC was required to or would be able to address perceived science learning challenges arising from workforce mobility; or
2. standardisation and control of the science curriculum would improve science teaching and learning.

Science specific influences:

Experts identified specific science-education influences on the NSC. These included:

1. student engagement with science and school science
2. national capability in science and supply of Australian scientists
3. creation of an informed citizenry participating in democratic decision making
4. comparative performance in international science tests , including variations in performance between States and Territories.

Student engagement

The intent of the NSC ,to promote student engagement with science, is explicit in the NSC documents as well as literature cited by the experts as influencing its design. A number of the experts mentioned the 'Framing Paper' and 'Shaping Paper,' some citing these verbatim. They commented on the explicit link of student engagement with *Science as Inquiry*, and *Science as a Human Endeavour* strands.

A lot of it was driven by concerns about student engagement with science so a lot of it was influenced by the Goodrum study (Goodrum et al, 2001) on the status of science. It was a fairly big factor in people's thinking. There was a big push to have more representation of inquiry approaches and quite a bit of contemporary thinking about investigative skills and notions of inquiry. This comes through. There's been a lot of critique like (Tytler, 2007) over emphasis on just declarative knowledge. That comes out too. So does Science for all (Fensham, 1985) and the science literacy notion of preparing citizens. The need to understand how science is used in society – a number of people pushed that.

While the intent was considered praiseworthy, they were skeptical as to whether a national curriculum could or would make a significant contribution to student engagement with science.:

At the end of the day I don't think that the curriculum will make a difference to students understanding and ability, even *their motivation and enjoyment of science. 'It's important to have a curriculum, but I don't want to ever overestimate what it can do.*

Informed citizenry

The need for citizens to understand science pertinent to significant national and international policy, as well as local decision-making, was considered important. Science issues of concern such as health, human-induced climate change and water management were among the examples mentioned. This was linked to notions of scientific literacy consistent with the OECD definition (OECD, 2009) with an expectation that science needs to contribute to a population capable of understanding current science ideas as discussed in the media, issues being addressed by government and a disposition towards rational thought based on evidence. Yet, four of the five commented on the absence of the term scientific literacy. They argued that this seemed at odds with the purpose of the curriculum; the literature considered influential in its development; and international trends in science education.

There has been a strong international trend in the last 20 years. A US-based trend looking at inquiry. Also, scientific literacy- I only noticed it once in document. It was in the draft (but) they took it out.

Interestingly, the strands most frequently described in positive terms as contributing to a scientifically literate Australia were the Science as a Human Endeavour and Science Inquiry rather than the Science Understanding strand. There was support for this emphasis in these strands, but dissatisfaction that it had not been taken further.

In Science as a Human Endeavour there was an opportunity missed to include dispositions like students' commitment to processes of using science, being committed to curiosity and finding scientific explanations that could be demonstrated in all kinds of different ways. There is a political problem with perceptions of touchy feely things, but if we could include something like that then it would force us to think clearly about what we want our kids to come out with. As it is, Science as a Human Endeavour is predictably about passive understanding about science.

Concerns were also raised about the emphasis on science disciplines at the expense of current interdisciplinary issues and problems.

Some of the big problems that the human species faces are interdisciplinary problems, but the curriculum is structured basically under sub strands as biology, chemistry, space science and physics. There are things like global warming, an inter-disciplinary ideas. So, where do we teach that and how do we deal with that?

National capability

Building national science capability was linked closely to student engagement. Engagement with science was considered as important for all citizens whereas capability emphasises participation rates in university science courses and the provision of science-able graduates to feed Australia's economic growth. In the context of providing a science curriculum that catered to the needs of a general public, as well as a science profession, some referred to the challenges of *Science for All* (Fensham, 1985). Student engagement with science through the primary and mid secondary years was considered important, but not sufficient to address diminishing interest in university science and science-based careers.

> *Collectively there has been this up-well saying that we need more students entering university to do science and engineering and mathematics. But, the solution needs to be much more complex than a political solution. This curriculum is a political solution to a number of interest groups pushing their barrows. I understand the political reasons and when you get physicists from a number of universities worried that they are not getting enough students and they put pressure on governments to do something about it. Then it comes back to, let's increase the emphasis on content or do something to the school curriculum.*

Significantly the senior science years were considered critical in building on early engagement with science as a lead into university study. This paper is avoiding analysis of feedback on the senior curricula. Nevertheless, most experts expressed severe reservations about the senior curricula, suggesting that the current drafts were likely to discourage future participation in science. Criticism, however, was tempered by the acknowledgement that the senior curricula were a work in progress.

International test results

It has become difficult to have any discussion about science education without consideration of international test data. Views of the influence of TIMSS and PISA on the curriculum were mixed. Some experts reported a difficult–to-understand dissatisfaction with the achievement of Australian students, despite evidence that Australian students perform well. Some indicated that it was not primarily a concern about current performance but a determination to prevent any fall on the international comparison tables.

> *I don't see the test results as a huge driver in the national curriculum. If we had done appallingly in those international tests, then that would be a driver, but the reality is we have done quite well internationally. For example PISA, we are in the second band, and only one nation was in the band above us. If anything we are further advanced than most other nations. Logically it could not have been the driver. But politicians, being who they are, would not like us to drop. They think we're slipping down the scale. We want to be as good as Finland. On an international scale, that's what it's about. We do very well, but we have a very long tail of students that do badly, that we*

need to do something about. But, I don't think that the curriculum can do very much for those students.

Others suggested that the NSC could be considered a means by which achievements of less well-performing states and territories could be brought up to match better-performing states. While considered a possible influence on the national curriculum, the argument was not considered strong because differences between State and Territory performance were far better explained in terms of factors other than curriculum, including variables such as age, socio economic status and educational opportunity - matters a curriculum is unlikely to address.

Different levels of achievement in states based on PISA tests or TIMSS tests, without an understanding of different entry levels and age level of students, might have encouraged a national curriculum. It seems easy for politicians to reduce differences by creating a national curriculum.

International tests such as TIMMS and PISA were regarded as a significant influence on current political thinking about schools science, but according to some not critical influences of the NSC.

On the other hand, others expressed the view that while the performance on international tests was not a major driver, the testing was influential in the curriculum. They noted that items in the Science Inquiry strand and Science as a Human Endeavour strand were consistent with PISA assessment

It was unclear, however, whether the curriculum was influenced by PISA or whether both the curriculum and PISA were influenced by the same trends in science education. Perhaps both are connected factors, as two experts referred to presentations by Fensham in which he had discussed some implications of PISA for Australian science curriculum development (Fensham, 2002). The general view was that setting out to use a national curriculum to improve rankings determined by international tests would be *bad for kids* and for Australian science. They contended that, fortunately, the NSC had not been excessively influenced by such a goal.

Is it a good curriculum?

Views on the quality of the NSC varied. All experts identified good features of the curriculum including the emphasis on Science as a Human Endeavour and Science Inquiry strands. Some experts described it as 'bland', 'uninspiring' and 'conservative'. Others described it as 'bold', 'good' and 'great'.

The national curriculum doesn't look too bad. At least it flows. It sort of makes sense.

The document is very good. I know there are problems. I do believe that the direction it is taking science education is good and that is a very real emphasis on pedagogy; getting kids engaged; and having the perceptions of what science is in the community, or the school changed. That's what comes through in the document or it tries *to come through. It gets a little lost in the detail.*

Overall, it is a great curriculum document for science. The national curriculum is about giving guidelines and direction. It is not a syllabus so I think in a sense they have been very bold ... in not writing a whole bunch of stuff in there that has to be learnt. That's taken guts, to be quite strong in resisting that temptation.

When asked whether the national curriculum was better or worse than their current state or territory curriculum (except for senior curricula) only one answered directly, indicating that it was better on the grounds it was less specific than the current state curriculum. Others responded by indicating ways in which their state or territory system was better and ways in which the national curriculum was better. The only consistent view being expressed was that the emphasis on Science as a Human Endeavour was an improvement on most current curricula.

Compared with traditional approaches, which focused very strongly on science understanding and maybe enquiry or process skills then Science as a Human Endeavour has a much stronger influence. That is an aspect of science that has been under-represented in curriculum documents previously.

All but one agreed that the national curriculum had not been able to translate the admirable goals and intentions of the 'Framing Paper' into the strands and lists of content. They also recognised that this is not unusual and was a significant challenge in a negotiated curriculum.

There are always fine words at the start and talk about creativity, reasoning and high level thinking, cultural usefulness and what have you. Then what you often got was very dry content coming out of it. I think there is a bit of that here. Maybe it is inevitable because, in part, content has to be specified. Often the high hopes that are expressed earlier, have to be expressed between the lines so to speak. It comes from a lack of imagination and the multiple influences that occur on people writing these things. You have all these jurisdictions clamoring for representation for the way they've always done things. I guess I'm being too critical. The three strands are an attempt to build on the Framing Paper. The critical thing will be what is done with it. It could be made consistent with the Framing Paper if teachers know how to do it. It is a pity the document didn't make it easier.

None of the experts were concerned with the detail of the content lists. Three raised concerns about the way in which assumptions had been made about what students were capable of learning according to age, and the consequences for school science learning. Some considered the curriculum to be too restrictive in organising the science understanding strand by school age levels. These experts argued that the level of specificity would act against the treatment of science in context. They viewed this as lamentable because the context and local connections were considered critical in generating and maintaining student engagement. All spoke with some passion, when citing instances where restricting the specific understandings to be learnt by year level was fundamentally flawed.

The way it goes from topic to topic at specific years - we have always grappled with this and tried to make it non-mandatory to do things at particular levels, … there are all sorts of reasons why you might want to find and follow what is actually growing in students' understandings. … Renewable energy, for example, which focuses on energy issues has a lot of focus on electricity because as soon as you start to have hands on experiments with wind turbines or solar cells, you need to know about electricity. It really causes a bit of a problem if you are looking at contextual units. It's hard to bring in that contextual stuff. If you look at matter, well particles don't appear until year 8 in the national curriculum. You are running around describing properties up till then. It is a very Piagetian view that drives it. Things like particle ideas are too abstract. And, if you can't get it absolutely right until adolescence, beyond concrete thinking - that is nonsense. There has been a lot of research in that area and kids are capable of far more than that. There is a kind of hang over in the document that at particular ages we can only challenge them to this level. If you talk about evaporative processes kids will talk about particles, they'll introduce it so if you want to teach kids about evaporation with one hand tied behind your back and blindfolded then that's fine. The argument is that if you introduce particles too early then they misunderstand it because they think they expand along with the stuff. They think there is matter in between instead of a vacuum, but who cares.

Nevertheless, leaving aside the restriction of content to age levels, some experts argued that descriptions of content were broad enough to allow for local context and school based development.

This curriculum does give the teachers a lot of flexibility and that's a good thing. So generally, it's not just a list of dot points of things to be taught in each year. It gives teachers professional license to develop appropriate programs for their specific students. It is written in a way that allows for change. It lets the teacher make decisions about what is the latest cutting edge science to include.

Others took the opposite view

The kind of specificity that we've seen in this document is going to cut across that and also there was some concern about the possibility of local variation, particularly schools making partnerships or *having projects based in local communities. If there is too much specificity then you lose the chance to go down that path.*

Notably, the various positions regarding specificity seemed inherently related to current state or territory curriculum documents. In those states where the national curriculum document was more restrictive than their current curriculum, the experts viewed this unfavourably. In states or territories with more restrictive current curriculum documents, the experts regarded this feature of the NSC as a step forward.

The experts were universally unconvinced that there was some universally right, logical order in which to present and build understanding of science ideas.

Experts were emphatic that teachers and schools need flexibility to create a science curriculum that caters for the needs and interests of students in their distinctive contexts. The main concern was not so much that the curriculum would prevent this, but that its implementation would.

Some noted that they were aware of arguments occurring in some states regarding whether 'topics' were presented in the correct order.

While there was significant criticism of the curriculum content lists, there was also acceptance that a relatively conservative curriculum is an inevitable product of extensive consultation with many influential stakeholders.

The rhetoric about the curriculum is that it is anything but conservative, but when you look at it is pretty conservative. I appreciate the political dilemmas and the reality is the product from any large curriculum project is not going to be ideal. Despite the spin of being classed as world- class the reality is that is it pretty uninspiring and it is just a list of things that could be done.

For some experts the national curriculum was viewed as a first iteration. Just getting a NSC in place may be a worthwhile and essential first step.

It's the first one we have ever had. Something that could be agreed to. It will evolve and change over time because I think there are too many players involved in this act to expect to have it right to begin with. We will have to mould it, shape it, and develop it as people interact with it.

Innovative or conservative

Experts were concerned about the curriculum implementation process and potential consequences of a national curriculum. Terms such as 'worried' about, 'concerned', 'fearful', and 'afraid' were used when the experts spoke of implementation effects. The concerns related to testing, the possibility of additional curriculum layers added by States and the loss of locally contextualised science.

The impact of anticipated national science testing was a concern. The view was that a NSC would make regular high-stakes national testing of science likely. Inappropriate use of National Assessment Program –

Literacy and Numeracy (NAPLAN) data and the MySchool website were cited as examples of the harmful outcomes that could be prompted by the NSC.

It depends on what or how NAPLAN pans out over the next few years and how it articulates with the NSC. If NAPLAN follows a certain pattern, it will become a pseudo curriculum. That concerns me ... . It is one thing to just list three strands but if the emphasis in the checking is going to be heavily on science for understanding, then the other two strands will be just ignored. Some teachers have been doing innovative work within broad guidelines and have largely been responsible for assessment rather than having some external assessor. I get a sense that the national curriculum will see a regression to much more conservative teaching.

It is anticipated that national testing will prioritise the science understandings strand. This would diminish emphasis on Science Skills and Science as a Human Endeavour; the strands in which the NSC provided an advance on current offerings.

All experts expect at least some states to impose another layer of curriculum development between the national curriculum and schools, although some do not expect this in their own state. All but one regard this as unhelpful, considering the curriculum sufficient.

It would pull the carpet completely out from underneath National curriculum. What is the point of having a new curriculum with all these new things in it if nobody does it? The whole point of spending money on developing a national curriculum is wasted. And people will continue doing what they are doing.

A layer of State curriculum or syllabus would recreate differences at a state level, something the NSC sought to eliminate. Funds available to support a NSC should, in the opinion of the experts, be invested in the development of resources and teacher professional learning, not in a syllabus. In this context, two fears were expressed. In states with a strong history of prescriptive curriculum, the view was that resources would be wasted on a syllabus, and little would remain for effective implementation in schools. In states with curricula described as broad frameworks, the fear was that the national curriculum would cut state investment in science education.

They may see this as a cost-cutting opportunity, cutting back on our curriculum developers and curriculum people in the Department of Education as a support.

A generally held view was that different State-based curricula would make the sharing of resources across state and territory boundaries difficult and less likely. Two experts were resigned to one state, at least, producing its own syllabus.

They are going to develop this syllabus. There isn't any other alternative. Simply they see that they are going to make the syllabus.

Professional learning and development
The NSC, will require significant professional learning and development for teachers. In some instances this will be required to support school-based curriculum development. One challenge will be to deliver on the intent of the Framing Paper.

> *The national curriculum is silent on how to do this. The framing paper says there will be less emphasis on a transition model of pedagogy but more on the model of student engagement and enquiry. It might have good intentions, you get hints but it doesn't really inform teachers on how they might do it.*

According to the experts the impact of the national curriculum on student learning and engagement in science depends relatively little on the curriculum per se. Rather it hinges on its implementation and the professional learning support for teachers. On the one hand, they perceive a risk of standardisation and testing producing a narrow, dull taught curriculum. On the other hand, there is hope that a rich science pedagogy maybe enacted to engage future generations.

Conclusion
The research was implicitly motivated by a desire to consider our science education future, because a curriculum cannot be judged by the words on the page but by its enactment. Hence, in responding to these questions the experts' views have been used to create two science curriculum future scenarios.

There is a complex interplay among stake holders that has produced a compromise curriculum. Experts largely agree on its strengths and weaknesses. Interestingly, despite this agreement, there is considerable variation in their perceptions of the goodness of the curriculum. Most of the experts saw the NSC itself as benign, but they were concerned about how it may be implemented and ill-used. Hence the quality and state of Australia's future science education with the NSC, is difficult to predict. Two very different scenarios seem possible. One emphasises state independence, standardisation, compliance and control. The other emphasises trust in teacher professionalism and knowledge exchange.

Compliance Scenario

In this scenario, the NSC improves school science through standardisation, surveillance and control. Support for professional development and school science within states is reduced because the work of curriculum development has been done centrally. Prescriptive resources are produced with activity sequences which classes follow. There is a national curriculum but some states introduce a syllabus. This restricts variations in schools within these states and prevents efficient sharing of resources across state boundaries. High-stakes national tests, based primarily on the easy-to-assess Science Understanding strand, are used as indicators of state, territory and national science achievement. Results are published and ranking tables appear in the media. The science curriculum becomes narrowly focussed on the acquisition of readily testable science information. Student engagement decreases and disenchantment with science increases but a small population of devoted science students thrive. Senior science becomes entrenched as a field for the elite but fewer students study senior science. National capability needs are met by a few, very able graduates from science degrees who pursue careers in science.

Trusting Scenario

The national curriculum provides a framework for consistency in science education across all states and territories. Students learn about the same key concepts and big science ideas within relevant contexts. There is an equal emphasis on Science as Inquiry, Science as a Human Endeavour and Science Understanding, which are integrated. Science proves attractive and engaging for many students. The shared curriculum across states promotes the sharing of science pedagogy. There is no net increase in support for science curriculum implementation but it is targeted at professional learning and provision of nationally applicable resources. National testing reflects the aims of the national curriculum, providing data on achievement as well as science dispositions. This data is used for diagnostic purposes to enhance science teaching and learning. A renewed interest in science in years K-10 leads to high participation in science in the senior years. In turn, university science degrees attract more students with a vast range of interest and abilities. Some of these students pursue a variety of career paths as researchers, in industry and education. The future probably lies somewhere in between.

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