

The development of the astronomy curriculum for New Zealand secondary schools

Robert Shaw

The Open Polytechnic of New Zealand

On 26 February 2004, the New Zealand Qualifications Authority extended the secondary school science curriculum. They set out what would be assessed for three unit standards in a new Domain called Astronomy. This paper records the intention behind those standards, the mechanics of the process that established the standards, and how the Carter Observatory established an e-learning platform to make the standards available to every secondary school student in the country.

History

When New Zealand re-established its examination system for secondary school students in 2002, officials converted all the existing School Certificate subjects to standards or levels of achievement and established a new award, the National Certificate of Educational Achievement (NCEA). The norm-referenced assessment system (School Certificate) that made one student compete with another was tossed out, and each student now is individually measured against criteria. A large part of the justification for this radical move was to address the poor secondary school retention rates. The challenge of the new system was to have hundreds of teachers all make the same judgements about student achievement in relation to written criteria. Unfortunately for the nation, this requirement for improved teacher performance came at the very time when effective spending on teacher pre- and in-service training was reduced. Hence, the crunch came, and the public for several years lost confidence in the national examinations system.

When examination prescriptions were converted to descriptors of achievement some subjects did better than others. Astronomy - which was not prominent initially - was trapped in a two-credit standard that mixed solar system dynamics with some equally homeless geology. Consequently, many science teachers ignored the standard and sensibly taught other things.

Rationale and strategy

It is one of those accidents of history that New Zealand has a national observatory established by Act of Parliament. That observatory is the Carter Observatory and its Act requires that the Board appointed by the Minister of Research, Science and Technology tends to how astronomy might be advanced in the national interest.

In 1993, that Board considered at length how it might fulfil its duty. After employing consultants and holding intense debate, the decision was taken that a modern interpretation of the Act would be that that astronomy should be used as a vehicle for science and technology promotion in the secondary schools. Members of the Board at that time included Mike Doig, Gary Wilmhurst, Chris Parkin, Phil Yock, Lynley Cunningham, Richard Bentley, and Robert Shaw.

In the debate about the way ahead, there were two critical documents. First, there was Heather Ware's proposal presented to the Board on 3 May 2001. Her task was to "prepare a business case, articulate a vision and recommend the strategic direction including the timing and extent of any capital funding required". The idea was to prepare a document that would focus on the market opportunities, and thus support an appeal to government for capital funding. Second, there was

the “Strategic Review and Proposal for Re-Development”, 12 April 2002, that was prepared by the Board and management of the Carter Observatory to brief the Ministry of Research, Science and Technology and the Wellington City Council on plans for the development of the Observatory. The secondary school project finally supported was innocuously present as an option in the Board’s 12 April 2002 paper, under the heading “Focus on a wider programme of astronomical and scientific learning”. The critical decision to advance this as being about secondary schools was taken at a Board meeting on 7 June 2002. The challenge of that decision was that there was little curriculum for the secondary school teachers to teach and science teachers generally were not well qualified to teach astronomy.

Accordingly, the Board decided to support a project to establish the curriculum, to draw upon volunteers, and to ask the New Zealand Qualifications Authority (the agency responsible for examinations) to assist. It is indicative of the strength of the qualifications system that officials were prepared to assist, and that there was a pathway of decision-making that could rapidly result in a change to the national curriculum. At the time the work was done the NZQA was running a major project to reduce the number of standards, and the astronomy initiative was contrary to that instinct.

The Board set out its rationale for the project saying it believes:

1. “Astronomy is a superb vehicle to promote science and technology subjects
2. Astronomy is a superb vehicle to promote science and technology as career options
3. Understanding astronomy can contribute to a students’ personal development
4. Maori astronomy and the astronomy of Pacific peoples should be taught in New Zealand secondary schools
5. Astronomy would strengthen science education by complementing conventional school subjects
6. Students ought to gain recognition on the New Zealand Qualifications Framework for learning in astronomy
7. Astronomy could be well provided for on the New Zealand Qualifications Framework if unit standards are established
8. Unit standards in astronomy could contribute to a wide range of awards
9. Distance education techniques are suitable to provide astronomy courses
10. A distance education course would make astronomy available to all students throughout New Zealand
11. A distance education course would be attractive to schools because it widens student choice, provides timetable flexibility, and has minimal transaction costs
12. Unit standards can be assessed in distance mode
13. Teaching secondary school students would help fulfil the Carter’s legislative responsibility
14. Being a specialised distance provider would be consistent with Carter’s responsibility to be New Zealand’s National Observatory. “

This list that inspired the Board is understandable if you reflect on the way the Carter Board is established. Deliberately the Board of our National Observatory is structured to provide a link between astronomy and the wider community. Accordingly, it is a Minister of the Crown who must appoint to the Board people from local government, education, and the business community. Astronomy is extremely fortunate in having this unique vehicle by which it might promote itself in

our capital city, for it breaks the model of scientists talking to scientists, and provides conduits into both central and local government.

Some members of New Zealand's astronomy community thought the new curriculum was for people like themselves. They thought it was for intelligent, energetic, high achievers, with a passion for astronomy. If this had been the proposed student cohort, the project would have stalled. The challenge for the education system in New Zealand is to assist those students most at risk of failure and who likely to leave school with no qualifications at all. The plan was to build upon the intrinsic worth of astronomy to promote further learning in science and technology.

Close to Government

The Observatory took care to ensure its aspirations were aligned with those of the Government. As the Carter Board recorded:

"The Carter enjoys a special relationship with the Government, and thus the Board wants to ensure that its work is consistent with the strategic directions being developed by the Ministry of Education. The present proposal contributes to these strategies, which have been identified by the Ministry of Education:

1. Raise participation and achievement for underachieving students
2. Give students access to a wider range of options
3. Better provide for Maori and Pasifika students
4. Take full advantage of information technology
5. Ease in-school resource constraints
6. Advance the goal of a strong research, science and technology workforce
7. Advance the skills of self-directed life-long learning. (Sources: Ministry of Education. 2002 Briefing to the Incoming Minister of Education; ICT Strategy for Schools, 2002-2004; ACER report on the science curriculum)"

As a part of its management of assessment standards, the New Zealand Qualifications Authority had set out requirements for its endorsement of new standards. Several groups, apart from those interested in astronomy, were interested in new standards, including the Industry Training Organisation for electro-plating, the Catholic Church, an interdenominational church organisation, and veterinary nurses. The requirements for new standards promulgated by NZQA were:

1. "There is a demonstrable need for the standard, it does not unnecessarily duplicate an existing registered standard and it represents an achievable outcome worthy of certification in its own right;
2. There is no unnecessary or unreasonable restrictions on the pace or mode of assessment;
3. The language of the standard does not create unnecessary or unreasonable barriers to access in terms of gender, ethnicity, or cultural background;
4. The content of the standard meets the requirements of the national standard setter and is within its area of responsibility;
5. The standards have been endorsed as being fit for purpose for the intended sector;
6. The national standard setter has evidence that both new and revised standards have been the subject of consultation with stakeholders;
7. The standards meet the specific quality criteria;

8. The outcomes in the standard are consistent with each other and the overall competence indicated by the title;
9. The outcomes are achievable, manageable, coherent, assessable, and consistent with valid assessment practice;
10. The standard is of publishable quality – free from spelling, punctuation, and grammatical errors, consistent, and meeting current formatting requirements.”

It is important to appreciate that a standard is an outline of what it is that the student can do at the end of a course of study, it is not a course outline and it gives no information on how the subject is best taught. Courses must be devised as a separate exercise. In other words, the development and management of standards is one thing, and the delivery of courses and the assessment of students is another.

The principal person at the New Zealand Qualifications Authority responsible for the astronomy initiative – the development of the standards - was Martin Eadie, Tertiary Education Group Manager, although many staff contributed.

The National Observatory's project

The Vision of the Carter Observatory regarding education was adopted after heated debate by the Board in 2001:

“The Carter Observatory will provide education and learning experiences in astronomy for the public, for students and for amateur astronomers that are both authoritative and stimulating; and which excite the young to seek further involvement with science and technology.”

Consistent with this Vision, the Carter Board adopted a further, more specific vision to guide development work over the next few years. That statement was to:

“Be a specialist ‘outside’ provider of astronomy courses for secondary school students, to assess student achievement and have students gain credit for this learning on the New Zealand Qualifications Framework”.

To pursue that vision, the Board endorsed six goals:

1. Establish unit standards for astronomy
2. Become a registered provider
3. Be accredited to assess the unit standards
4. Produce, and deliver, a distance education course
5. Be funded by the Ministry of Education on a per student basis
6. Work in partnership with schools throughout New Zealand.

To work on the standards an “expert panel” was established. This was co-chaired by Phil Yock and Michael Peters. Both held professorial positions at the University of Auckland, Dr Yock in astrophysics and Dr Peters in education. The panel consisted of secondary school science teachers from throughout the country, many being recruited at the science educators’ conferences. The Royal Astronomical Society of New Zealand also appointed their person, Marilyn Head, and John Field represented the Carter Observatory. Robert Shaw was the secretary to the panel as he had an operational role in the development of the standards.

A significant national consultation was held in several stages. The focus of the consultation had to be on the desirability of establishing standards for astronomy, but at the same time information was gained on the level of support for the Carter being a provider of secondary school courses in astronomy. Twice, all the secondary schools were provided with a questionnaire and the astronomy community was consulted through the Royal Astronomical Society and by direct appeal to observatories and people known to be interested in astronomy. Formally, the following organisations were consulted: NZ Post-Primary Teachers Association, science teachers' organisations, school boards of trustees, school principals and their association, the private schools through their organisations, university and polytechnic teachers, The Royal Society of New Zealand, several Maori organisations, a Pacific Island organisation, and a raft of government science and policy agencies.

The first formal consultation was in late 2002, and not at an ideal time from the point-of-view of schools. The results showed a good level of support for the initiatives. Not one school said the project should not proceed. Several useful suggestions were made on the standards themselves, and there was strong support from secondary schools for the Carter being involved in teaching their students in a partnership arrangement. Everyone said they would welcome the National Observatory taking a lead in astronomy education and some teachers asked the Carter to provide regular teacher in-service education.

Meetings with teachers and the panel considered a framework for the development of the Domain Astronomy. The plan was that the unit standards be in four vertical strands with unit standards at each of three levels as follows:

“Investigation and research

L1 Observe the sky

L1 Build a telescope

L1 Record the sun's activity

L1 Space

L1 Internet research skills

L2 Use an observatory

L2 The Hubble

L2 Internet data streams

L2 Astronomy observation techniques

L3 Practical construction project

L3 Systematic observation project

L3 Practical internet based project

Basic astronomy

L1 Night sky

L1 Ancient astronomers

L1 Modern astronomers

L1 Seasons

L1 Tides & Wanderers

L2 Planets and moons

L2 Extraterrestrial life

L2 Comets, meteors and meteorites

L2 Physics for astronomy

L3 Physics for astronomy
L3 Astronomy investigation

Ethno-astronomy

L1 Maori

L1 Myths & legends

L1 Pacifika

L2 Non-Pacific

L3 Ethno-astronomy investigation

Cosmology

L1 Our Universe

L2 Before Einstein

L3 After Einstein

L3 Physics for Cosmology"

From this proposed curriculum pattern, three level 1 standards were selected for immediate development. They became:

20621	4 Credits	Demonstrate knowledge of space exploration
20622	4 Credits	Demonstrate knowledge of our solar system
20623	4 Credits	Demonstrate knowledge of the Milky Way, our galaxy.

There were several key decisions taken about the Domain Astronomy standards and some decisions were hotly contested:

1. They would be Unit Standards and not Achievement Standards. New Zealand ended up with two systems of standards for schools. There are Unit Standards managed by the New Zealand Qualifications Authority and these adhere to the original design for the standards system. There are also Achievement Standards which have a more complex approach to both definition and moderation, and for which the lead agency is the Ministry of Education. The project team did not believe it would be possible to develop Achievement Standards because of the political and bureaucratic systems they involved.
2. The "cultural" aspects (particularly Maori) of astronomy would be integrated with the physical science. The alternative was to produce a separate Maori astronomy standard, *Taatai Arorangi*. This remains as a worthwhile objective. It is attractive to many schools and particularly to Maori and Pasifika people interested in the cultural activity around ocean sailing and the use of astronomy in navigation and ritual. However, the project team decided that for the initial three standards the approach would be integration.
3. The Carter Observatory would develop standards that could be used by any secondary school in New Zealand. The alternative was to seek to have an accredited course that only the Carter could teach and assess. This would have assisted the Carter's business objectives, but would not have addressed the national need consistent with its role as the National Observatory.
4. The standards would not include a requirement for practical astronomy. Practical astronomy was not precluded as a part of any teaching programme, but it was not be mandatory that it be assessed. The reason for this was to make the standards as accessible as possible. It meant that they could be entirely taught and assessed on the internet.
5. The standards would not include solar system dynamics – because new standards cannot have the same content as existing Achievement Standards. This does not mean that

teachers cannot teach solar system dynamics, just that their assessment of this topic will not be audited in the formal moderation process. Wonderful are the ways of public administration.

Teaching

Once it became a registered and accredited private education provider, The Carter Observatory built an online teaching platform for the astronomy standards. This platform is unique for several reasons.

1. The platform is designed for our less able New Zealand students and specifically for the subject astronomy. It is not a generic programme and hence it has a strong consistent theme. Students are supposed to see it as a little old-fashioned, reliable, conservative, and to represent work, not play.
2. The presentation of course materials is specifically directed at the needs of the less able students and courses adopt a language-learners' approach to the subject astronomy. The program shuns distractions such as clever interactive demonstrations and student chat. Students are motivated and kept on-task by the structure of materials and motivation around the acquisition of credits.
3. The assessment is strictly criterion-based and cumulative. This contrasts with the norm-referenced assessment systems that are inherent in the online teaching packages that are used by universities around the world. In other words, the astronomy students are rewarded as they achieve each objective and they are never given a mark out of 100, or any numerical mark at all for that matter. The use of percentage marks is indicative of norm-referenced systems whereby students are ranked against each other. This feature of the platform has caused difficulties with the New Zealand Qualifications Authority as it has been necessary to introduce each new generation of moderators and auditors to the idea that a provider has been true to the design of the New Zealand qualifications system. Equally, the Ministry of Education did not have the statistical categories needed for a system that did not give students a grade, A, B, C, D or E. Nor could they cope with courses that could be begun at any time during the year and have variable completion dates over two years. Statistical returns are for ordinary people. These problems were all resolved with good grace and apportionment.
4. One outcome of the assessment system is that the students can genuinely work at their own pace, and whenever they wish. The experience of the Carter has been that some students work at strange hours but generally they work at school or at home before 11 pm. It is now possible for students to be assessed for astronomy credits in their school holidays and independently of their school.
5. The system incorporates a very tight marking schedule that the teachers use to assess the students' responses online. Accordingly, the present author whilst on sabbatical at the University of Illinois taught and assessed in real-time students from Taihape.
6. The teacher response time is critical to the motivation and learning of the student. It has been shown that individual students in the Carter system can gain more personal attention than typically they can achieve in a normal classroom. When fully operational there is a duty teacher monitoring the system 24/7.

Change in direction

The Ministry of Research, Science and Technology funded a review of the Carter Observatory in 2005. That review was carried out by experienced research astronomer Professor Mike Bessell, of the Research School of Astronomy and Astrophysics at Australian National University.

Apparently, he did not meet the Board of the Carter (the present writer attended all the Board meetings during the period of the review), or consider the documents from the strategic planning process (according the chief executive), or establish the unique and special place the Carter has in the Colonial history of Aotearoa, or talk with Maori or Pacific Island people, or talk to secondary school teachers, or contemplate the advantages to astronomy of the Carter's governance structure as described above.

However, Dr Bessell decided the Carter's Act should be repealed and that it should not be our national observatory. He wrote: "The Carter Observatory should be rebadged to recognise its leadership in astronomical education and its national role in teacher support and on-line learning", but he failed to see that in New Zealand this very role was the national need and that the "badge" of national observatory gave to the Carter a base of authority that is necessary to take a leadership role in astronomy education.

The Government never made a definitive declaration about the report. Science officials said they would contact other officials in departments concerned with education, Maori, and local government. However, faced with a report of no confidence, the Carter Board had little choice but to develop the Carter as a first-class visitor attraction and facility for the Wellington region, and to turn away from what it once saw as its national responsibility.

The decision was taken by the Carter Board in mid-2007 that the Observatory would no longer teach secondary school students online and to allow its New Zealand Qualifications Authority registration and accreditation to lapse.

Reflections and prospects

It is remarkable that the New Zealand qualifications system allows new qualifications to be established so quickly. This flexibility stands our country in good stead as it proceeds in an age of rapid change that includes the emergence of new requirements for skills and abilities.

It was also remarkable the way different sectors were able to work together with Government officials to pursue the goal of science and technology promotion. The need to attract more young students into science pathways has been known for over 30 years and there have been very few successful projects. The idea of changing the base curriculum for secondary schools is rather obviously the way to advance - and that is a strategy of Government, working around the idea of literacy.

When the Education Minister, the Rt Hon Trevor Mallard, on 11 May 2004, opened the astronomy distance education facility he spoke about the importance to science teachers of a specialist off-site facility directed at astronomy. Astronomy is the subject to inspire the teachers as well as the students. The Carter's facility has already proven itself as a vehicle for informal teacher education. It is a cost-effective way to provide a physics teacher for every secondary school in the country, when we are so desperately short of physics teachers.

That the nation's science curriculum should depend for its development on volunteers and grants from licensing trusts should be noted. The Carter Board, led by successive chairpersons Mike Doig and Richard Bentley, took an heroic step when it decided to launch into a project in the national interest without any financial backing. The Board did manage to alter the secondary school

curriculum and open up the possibility for science teachers that they can teach astronomy and have their students rewarded for their achievements in that subject. Several aspects of the project have been recorded (Shaw, 2004a; Shaw, 2004b; Shaw, 2007a; Shaw, 2007b; Shaw & Love, 2007).

Schools are starting to teach astronomy again. Many start with their year-9 students and do not necessarily have their students seek astronomy credits. Individual students throughout the country have been able to fund themselves into astronomy courses or been supported by Trusts. At its peak of operation the Carter taught 350 students online and the teaching platform holds the potential to teach several thousand students without difficulty.

Teachers frequently ask for in-service courses in astronomy education. This could be provided building upon the useful base of local research into student spatial learning (see for example, Coll, France, & Taylor, 2005; MacIntyre, 2005).

With the withdrawal of the Carter Observatory from secondary school education, there is a need for an organisation to champion the management and development of the astronomy standards. The standards cannot simply sit on the books of the New Zealand Qualifications Authority without being refreshed. There is also a demand from students for standards in cosmology and Maori astronomy. Potentially, there is an opportunity for the Royal Astronomical Society of New Zealand to take a lead role, in partnership with the New Zealand Qualifications Authority.

The annual conferences of the Science Educators' Association (SciCon) were important during the development project. They provided an opportunity to debate issues and support beginning astronomy teachers. Frequently, teachers asked for a book to support the new standards. They wanted something that authoritatively and precisely defined the curriculum. A unit standard is only an outline of what must be assessed, it is not a course, and without a book it requires a great deal of work for any teacher to begin to teach the astronomy. This was the genesis of the *Astronomy Aotearoa* resources (an integrated textbook, student workbook, and website) published by Pearson Education New Zealand (www.astronomyaotearoa.net). The textbook was launched by the Hon Luamanuvao Winnie Laban on 17 September, 2007 at Aotea College, Wellington.

Coll, R. K., France, B., & Taylor, I. (2005). The Role of Models/and Analogies in Science Education: Implications from Research. *International Journal of Science Education*, 27(2), 183-198.

MacIntyre, W. (2005). 3d Modelling: Demonstrating Understanding in Science. In J. M. Pasachoff & J. R. Percy (Eds.), *Teaching and Learning Astronomy: Effective Strategies for Educators Worldwide*. Cambridge-New York: Cambridge University Press.

Shaw, R. (2004a). *The Black Hole Theory of Teaching: The Future of Assessment and Course Delivery in New Zealand Secondary Schools*. Paper presented at the New Zealand Post Primary Teachers' Association Conference: Charting the Future, Wellington, 18-20 April 2004.

Shaw, R. (2004b). *Towards a Heideggerian Pedagogy*. Paper presented at the 33rd Annual Conference of the Philosophy of Education Society of Australasia, Melbourne, 26-28 November, 2004.

Shaw, R. (2007a). *Astronomy Aotearoa*. Auckland: Pearson Education New Zealand.

Shaw, R. (2007b). Pedagogic Thinking That Grounds E-Learning for Secondary School Science Students in New Zealand. *E-learning*, 4(4).

Shaw, R., & Love, D. (2007). A Heideggerian Analysis in the Teaching of Science to Maori Students. *He Kupu*, 2 (forthcoming).

Robert Shaw teaches business analysis at the Open Polytechnic of New Zealand. He is a former secondary school physics teacher and head of department, and a former member of the Board of the Carter Observatory. He has been an official in the Ministry of Education and the Ministry of Research, Science and Technology.