Science in the Māori-medium curriculum: Assessment of policy outcomes in Pūtaiao education

GEORGINA STEWART

University of Waikato

Abstract

Science and science education are related domains in society and in state schooling in which there have always been particularly large discrepancies in participation and achievement by Māori. In 1995 a Kaupapa Māori analysis of this situation challenged New Zealand science education academics to deal with 'the Māori crisis' within science education. Recent NCEA results suggest Pūtaiao (Māori-medium Science) education, for which a national curriculum statement was published in 1996, has so far increased, rather than decreased, the level of inequity for Māori students in science education. What specific issues impact on this lack of success, which contrasts with the overall success of Kura Kaupapa Māori, and how might policy frameworks and operational systems of Pūtaiao need to change, if better achievement in science education for Māori-medium students is the goal? A pathway towards further research and development in this area is suggested.

1: The historical and philosophical context of Pūtaiao (Māori-medium Science) education

Although the word 'science' in one sense means 'systematic knowledge,' it usually refers to what is more precisely termed 'natural science': i.e. physics, chemistry, biology, and the sub-disciplines thereof. Mathematics, also a science, is usually delineated separately in the school curriculum, due to its perceived importance (Tymoczko, 1994; Hersh, 1994). This assumed meaning is important in considering science's leading position in hierarchies of knowledge. In literature specifically concerned with the relationship between science and other cultural forms of knowledge (MORST, 1995; Williams, 2001; Simon, 2003), this meaning of 'science' is often made explicit by such usages as WMS, short for 'Western modern science' (McKinley, 2005), WS (Roberts, 1998) or W-science (Kawasaki, 2002). I use the term 'W-science' below when necessary to avoid ambiguity. The appearance of many meanings of, and qualifiers for, 'science' indicates its contested nature: the debate over 'what counts as science' (Stanley and Brickhouse, 1994). 'School science', for example, refers to the simple/simplistic version of science presented in the traditional school curriculum, which helps establish and maintain the assumed meaning, and its distinction from mathematics. 'School science' is also a useful approximation of what is meant by 'W-science' in the multicultural research literature.

A process of critique and deconstruction of the classical view of science (that is, as a type of knowledge which is purely factual, objective, a-cultural, etc) has taken place over the last 50 years or so (Hanson, 1958), in association with the development of the new philosophical traditions of postmodernism and poststructuralism (Peters, Hope et al., 1996). This critique of science has included the assertion that 'other' (Spivak, 1987) knowledge systems, such as indigenous knowledge, of which mātauranga Māori (traditional Māori knowledge) is a specific example, may validly claim to be alternative forms of science (Peters, 1993); an argument, in other words, for a culturally pluralist view of science (Hodson, 1999). A pluralist view of science tends towards the wide definition of 'systematic knowledge', opening the gates to the inclusion of an increasing range of knowledge bases, as human culture becomes increasingly sophisticated and systematized (with the help of W-science and W-technology). It becomes more difficult to identify areas of knowledge that remain firmly outside the gates of pluralist science (Irzik, 2001). One result of the pluralist view of science, therefore, is to *necessitate* the use of a qualified term such as W-science or natural science, to

signify the more limited meaning of 'science', although, as noted above, outside specific critical fields of scholarship, 'physics, chemistry and biology' remains its generally assumed meaning (Gregory, 2001).

The word 'pūtaiao' is now generally accepted as the Māori word for 'science'. Pūtaiao is used to mean either translated W-science, or traditional Māori knowledge equated with an alternative, non-Western form of science, and often there is little if any distinction made between these two usages. In other words, the equivalent of the 'W-science' terminology is not yet commonly seen in Pūtaiao discourse, even though it is equally as relevant (if not more so) as in English. The problem with this undifferentiated dual concept of pūtaiao is that it encourages and masks elision of the two meanings. As a result, the inherent dialectical issues related to language and knowledge, philosophy and politics become less visible, and hence more difficult to address, in the design and implementation of Pūtaiao teaching/learning/assessment programmes.

To speak of 'language and knowledge issues' indicates the assumption that knowledge and language can be separated, at least to the extent that issues can be identified as one or the other. However, since knowledge is carried (in classrooms) mainly by language, and since any use of language involves knowledge, clearly any issue of language is also an issue of knowledge, and vice versa. But a language is a system of codification of meaning, not a system of knowledge, which is how the term 'a science' is generally understood in its wider sense (as opposed to the W-science sense). At the same time, according to Michael Halliday, '[t]he grammar of every natural language is a theory of human experience: a theory that we hold unconsciously, but that is all the more potent for that very reason' (Halliday, 2004, p.9). These are significant distinctions and intersections forming and complicating the theoretical nexus of Pūtaiao (McKinley, 1995).

In the last few decades, the number of children in Aotearoa New Zealand learning in Māori-medium programmes, particularly in kura kaupapa Māori (KKM; primary) and wharekura (secondary) has entailed a commitment by the state to support and resource Māori-medium education, a commitment mandated by the Te Aho Matua section in the Education (Amendment) Act 1999. The production of Māori curriculum statements (marautanga Māori) was part of the development of the National Curriculum Framework/Te Anga Marautanga o Aotearoa in the 1990s, and subsequent curriculum initiatives such as exemplar production and curriculum-based professional development. The development of Māori science education as the subject 'Pūtaiao', and of the Pūtaiao document (M.O.E., 1996), have been part of this overall Māori-medium curriculum process.

Beyond the dialectic between W-science and Māori science in Pūtaiao, there are also wider curriculum dialectics operating in science education to be considered. Debates between 'science for scientists' and 'science for all' influence the science curriculum (Haigh, 1995), as does the tension between the perspectives of science educators and those of other 'stakeholders' such as business and the economy (Bell, Jones et al., 1995). The dialectic of 'science for all' versus 'science for future scientists' is related to a perception of the need for high science achievement to maintain international competitiveness, and also the importance of scientific literacy for the citizen of today's world. These considerations lead to policies that increasingly place Science, along with Mathematics and Technology, at the core of the compulsory curriculum. Schools and teachers grapple with the resulting difficulties, caused in part by a traditional science curriculum based on positivist principles, and resistant to reform efforts (Blades, 2006), that is incompatible with the personal culture of all but a tiny minority of secondary students (Aikenhead, 2000). The influence of constructivist science teaching pedagogy has also created polarities in science education in Aotearoa New Zealand during recent decades (Matthews, 1995; Bell, 1995), although acceptance of a weak version of constructivism appears to prevail (McMillan, 1995; Carson, 1997, p.111). A Kaupapa Māori critique of constructivist and traditional forms of science education is the focus of the following section.

Based on my personal experience, and in common with other views, (Gilbert, Hipkins et al., 2005; McPherson Waiti, 1990), I would describe Pūtaiao teaching as 'problematic', for several different reasons: knowledge and worldview clashes between 'science' and 'Māori'; the exploding number of kupu hou (science vocabulary) that teachers and students need to master as the class level increases, especially after

about Year 8; and the **lack** of teaching resources, facilities, professional development, etc - a 'vacuum' of professional practice (Irwin, 1999; McKinley, 1997; McKinley, 2007). Low achievement in Science is reported as the only negative 'key finding' (out of four) concerning the achievement of Māori-medium students, in a recent Ministry of Education report based on NCEA (National Certificate of Educational Achievement, the current national secondary qualification) data (Murray, 2007). This finding is consistent with the survey of NCEA Pūtaiao/Science and Pāngarau/Mathematics examination data, presented and discussed in the third section below. The final section presents an outline of Pūtaiao education as Kaupapa Māori Science education as a way around these difficult issues, and a pathway forward for further research and investigation.

2: A Kaupapa Māori perspective on 'the Māori crisis' in Science education

In an article published over a decade ago, Graham Hingangaroa Smith (1995) commented on the inability of constructivist as well as traditional/liberal science education to overcome Māori underachievement. Smith issued a challenge to 'New Zealand science education academics', to the effect that their international reputations 'ought' to rest on their 'ab[ility] to deal with domestic issues', particularly 'the Māori crisis' (p.119), as he termed the longstanding disparity in science education outcomes for Māori students. Smith critiqued not only the constructivist position on science education, but also the prominent critic of constructivism, Michael Matthews (1994), noting

> a contradiction in Matthews' position [with respect to the politics of Māori knowledge], on the one hand arguing against 'social constructedness' and yet on the other demonstrating quite clearly the social constructedness of science in the privileging of selected definitions of science. (p.105)

Smith called on Māori scholars to engage with Matthews' claims concerning Māori forms of knowledge (Smith, 1995, p.105). One of Matthews' key claims is that the notion of Māori science is not only invalid but harmful, because 'Western science and indigenous knowledge are in *different* categories of human endeavour' (Matthews, 1995, p.147, original emphasis). One might, in reply, point out that they are not *entirely* in different categories, in the sense that mātauranga *does* claim to inform science, in certain areas. This claim underwrites the validity of research in the human sciences and in ecology that draws on mātauranga, such as that of Mere Roberts and her colleagues (e.g. Roberts, Haami, et. al., 2004). Given the role played by 'consensus' in the standard account of science (Loving, 1997), the existence of scholarship in support of this view, such as Boyd (2001) and Lacey (2001), suggests this is a scientifically 'legitimate' position to take, according to the contemporary canons of post-positivist science. This demonstrates that Matthews, in this argument, falls prey to the trap of scientism (Charlesworth, 1982).

Smith argued that Kaupapa Māori is able to 'rescue' constructivism, by extending reform to 'structural considerations' such as 'power-relations':

> Māori social, political, economic and cultural subordination to the dominant group is manifested in many ways including the control over knowledge and the curriculum. What counts as science in the school represents a selection of knowledge which sometimes leads to the exclusion of Māori interests. (p.116)

Another 'structural' consideration cited by Smith is that of

> Ideology: there is a need to respond to Māori aspirations in relation to the validity of Māori language culture and knowledge revitalisation, particularly at the ideological level. There is a need to assert the validity of Māori knowledge and frameworks (ibid).

Here 'ideology' is used in the sense of the 'philosophy', 'central value' (Lacey, 1999) or 'essence' (Heidegger, 1977) of W-technology and W-science. Smith's paper opens some important questions for

Pūtaiao, which I should like to pursue further. For example, Smith clarifies at the start that his 'paper does not purport to engage deeply with epistemological or ontological issues of constructivism deriving from the question of "what ought to count as science?"' (Smith, 1995, p.105). He follows 'a sociological perspective' on knowledge:

> The critical insight here is that the school curriculum represents a selection of knowledge made by dominant non-Māori interest groups. In this sense, school science which is reified as neutral, acultural, and value free is clearly open to challenge. (p.108)

Yet from these quotes, it seems the question of 'what counts as science?' is central to Smith's ideas about how science education needs to change. Therefore, while raising the question of 'the Māori crisis', the advice for science educators in this paper is limited to a call for 'reorganisation at the pedagogical level in order to deliver more effectively for Māori' (p.119). Smith sums up his perspective as follows:

> I see tremendous potential in the constructivist approach, but at the same time, Matthews also makes some important criticisms. I would hold to the position that both schools of thought can be accommodated within an eclectic approach to science education and do not necessarily need to be constructed as an absolute oppositional discourse. My overriding concern is to seek the best approach for delivering success in science for Māori students. (p.109)

The overall conclusion of Smith's paper was that development of science education in Kura Kaupapa Māori would be required to overcome the longstanding disparity in outcomes. This article, published in 1995, pre-dated the publication of the Pūtaiao document; it appeared at a time when only a handful of Kura Kaupapa Māori (KKM) programmes included any Year 11-13 students. Discussions were then taking place between individual kura (schools) and NZQA (New Zealand Qualifications Authority), concerning translation of School Certificate examination papers into Māori for wharekura students. With the intervening growth and development of wharekura, it is timely to revisit the hopes and concerns Smith expressed in this paper.

3: NCEA Pūtaiao and Pāngarau

This section looks at recent results for Māori-medium students sitting NCEA Science/Pūtaiao and Mathematics/Pāngarau examinations. This follows a well-established view of secondary qualifications data as a measure of educational success (McKinley, Stewart et al., 2004; Baker, 1993; Jones and Martin-Jones, 2004; Spolsky and Shohamy, 1999). First, the current systems for senior secondary curriculum delivery, and assessment for qualifications, are introduced. Then examination results are presented for the first three years of Level 1 NCEA, in Pūtaiao and Pāngarau. Despite the compelling 'text' offered by the following data, a strong cautionary note must be taken, due to various factors, including the very small size of the Māori-medium cohorts (ranging from 12-71 students sitting each examination paper in any one year). Because of this, the data are suggestive only, with limited validity to represent the populations concerned, and any conclusions drawn necessarily speculative.

Small cohorts in senior secondary levels remain extremely challenging for Māori-medium curriculum delivery. To address this, in recent years the Ministry of Education has provided video conferencing (vidcon) equipment and support for distance teaching/learning in wharekura nationally, in an initiative called KAWM, acronym for Kaupapa Ara Whakawhiti Mātauranga, which can be translated as 'Distance Education Project'. KAWM is currently an important means by which Pūtaiao and Pāngarau are taught in wharekura Year 11–13 throughout the country, with student numbers predominantly in Year 11 or NCEA Level 1 courses. The extra linguistic and cognitive demands on teachers and students in this attenuated pedagogical situation are considerable - as are the limitations. For example, in order for the vidcon gear to function (that is, not to drop the live link), KAWM lessons must be teacher-focused - whiteboard and/or text based, with a lecture, demonstration, or limited discussion style of interaction. More active teaching strategies such as practical or group work are not encouraged by the technology. Nevertheless, despite the limitations, the shortage of

senior Pūtaiao/Pāngarau teachers, and the high importance placed on these subjects by kura whānau (school communities), together constitute a strong imperative for wharekura to participate in KAWM. Under KAWM, a teacher in one wharekura becomes the national teacher of e.g. Level 1 NCEA Pūtaiao. The teacher's home classroom lessons are also accessed, via vidcon, by students at up to 10 or more other wharekura around the country. One Level 1 NCEA Science textbook (from Newhouse Publishers) has been translated and web published, to support this Pūtaiao course. A further support initiative has been to hold wānanga (live-ins) for a few days each year, where teachers and students from around the country can meet and get to know each other, address concerns, etc.

Māori-Medium Examinations:

Consultation with Māori during the NCEA development process led to the undertaking that the new qualification would be fully available to Māori-medium learners. Prior to 2002, for several years, SC Mathematics and Science examinations had been translated into Māori each year, under limited arrangements made between NZQA and individual wharekura. With the introduction of NCEA at Level 1 in 2002, examination translation was systematized, with schools able to request 'Te Reo' examinations during the candidate entry process, for any candidate entering externally assessed Achievement Standards.

Because of this system, the data for students sitting translated papers can be easily obtained from NZQA. These cohorts can be approximately equated with the student cohorts attending wharekura or Rūmaki/Immersion schools and units. As requested, NCEA examinations are translated into Māori by NZQA contractors. The translated papers are currently produced as bilingual examination booklets of twice as many pages as the standard papers, with the Māori and English versions of each page side by side. The translator attempts to include, in footnotes, all Māori terms in known use for the scientific vocabulary in the translated papers. Candidates may write answers in English or Māori (or both). One marker for each Achievement Standard marks translated booklets as part of their allocation, and unless that person is competent to mark in Māori, they are assisted by another person able to read Māori, who translates into English whatever the student has written in Māori, so the marker can mark it.

Thus, this system makes allowance for Māori-medium students by translation of an 'end-point' – an already finalised examination paper. This is allowance 'by language only' (McKinley, 1995, p.44) - there is no opportunity for Māori input into what is examined. Just as the Pūtaiao curriculum document 'is not considered to be a Māori curriculum' (p.55), neither can these translated examinations be considered distinctively Māori science assessments. The assumption is that the content knowledge to be assessed is exactly the same in wharekura as in mainstream schools: indeed, it is reasonable to suggest this system constitutes added motivation to teach a mainstream science programme, since wharekura wish to maximise student achievement.

To date, while some senior wharekura students have gone on beyond Level 1 Science and Mathematics, the numbers entering Level 2 and 3 examinations are currently very small (typically less than five students per cohort), and the papers are usually answered in English, so this area of Māori-medium science education can fairly be described as 'embryonic'.

Examination Data:

The 11 Level 1 NCEA Science and Mathematics external achievement standards, included in this discussion, are listed by ID number, title and credit value in Whika 1 below. These data omit internally assessed achievement standards, and unit standards, because the Te Reo/wharekura data for these are not available as separate cohorts from NZQA, since the entries do not involve translated papers. For each achievement standard, for each year (2002, 2003, and 2004), examination results were obtained for three cohorts: All

candidates, Māori candidates, and Translated paper candidates. The Māori cohorts are approximately ten percent of the size of the All cohorts, and the Translated paper cohorts are of the order of one percent of the Māori cohorts. For each cohort, four raw numbers were obtained, i.e. the number of candidates awarded a grade of Not achieved (N), Achievement (A), Merit (M) and Excellence (E). The original data set obtained from NZQA is listed in the Āpitihanga (p.12).

These numbers were manipulated to generate three non-overlapping student cohorts: Māori candidates were subtracted from All candidates to obtain figures for Non-Māori candidates; and Translated paper candidates were subtracted from Māori candidates to obtain figures for Māori Mainstream candidates. Translated paper candidates were identified as Te Reo candidates.

Year-to-year variability has been a significant national issue raised about the new qualification, NCEA (National Certificate of Educational Achievement), and the data set used here relates to the first 3 years, where 'teething problems' were arguably able to be blamed for at least some of the variability. Since there seems to be no useful information to be gained by tracking over these 3 years, the figures for 2002, 2003, and 2004 have been summed by cohort, for each achievement standard. This increases the size of the Te Reo samples, while simplifying the data presentation, hopefully without significant distortion. The summed figures for each cohort were used to calculate the following two measures of achievement, tabulated in Whika 1:

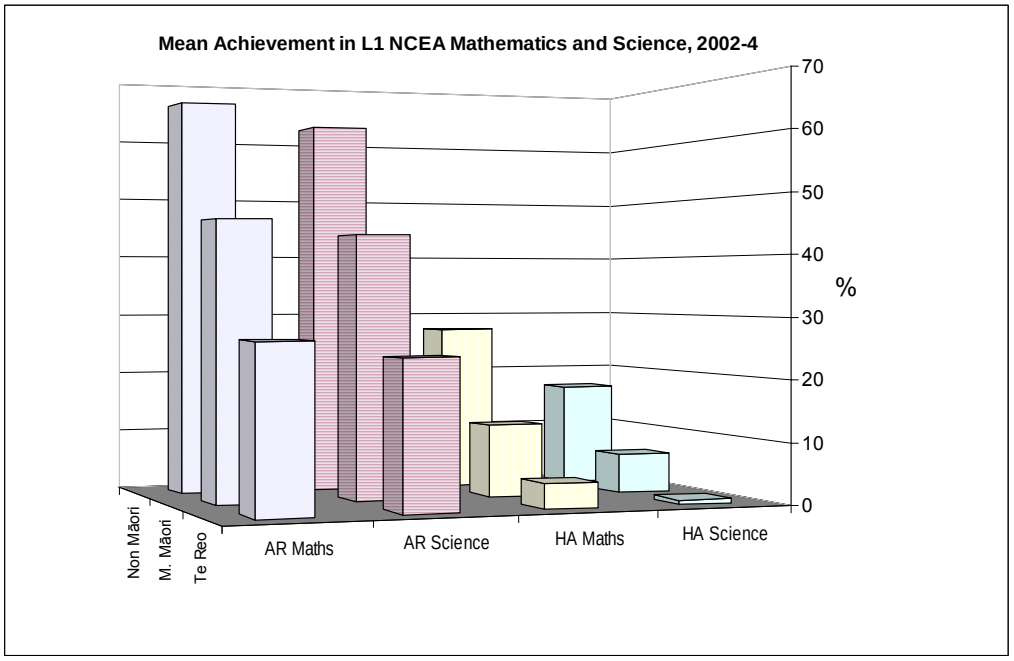
- **Achievement Rate (AR)**: Candidates achieving the standard as a percentage of all cohort candidates (A+M+E/N+A+M+E x100).
- **High Achievement (HA)**: Candidates gaining a Merit or Excellence grade as a percentage of all cohort candidates (M+E/N+A+M+E x100).

The same data are presented in graph form in Whika 2, p.8 below, where the data for individual Achievement Standards have been grouped again into 'Maths' and 'Science'.

Whika 1: NCEA L1 Science and Mathematics Examination Results

Achievement Standard No. (L1 credits) Title	Cohort	AR (%)	HA (%)
90188 (5) Describe uses and effects of micro-organisms and the transfer of genetic information	Non Māori	55.2	14.3
	Mainstream Māori	35.0	5.3
	Te Reo	20.0	1.3
90189 (5) Describe properties and reactions of groups of related substances	Non Māori	63.8	26.1
	Mainstream Māori	42.1	10.0
	Te Reo	14.8	0.0
90190 (3) Describe rocks and minerals	Non Māori	58.3	18.3
	Mainstream Māori	37.2	4.3
	Te Reo	21.3	2.7
90191 (5) Demonstrate an understanding of physical systems	Non Māori	66.9	17.1
	Mainstream Māori	48.2	6.3
	Te Reo	33.3	0.0
90192 (5) Describe spatial relationships in astronomy and their effects on space exploration	Non Māori	67.8	16.5
	Mainstream Māori	50.0	6.6
	Te Reo	24.6	0.0
90147 (3) Use straightforward algebraic methods and solve equations	Non Māori	61.6	28.1
	Mainstream Māori	40.1	10.9
	Te Reo	20.6	2.5
90148 (3) Sketch and interpret linear or quadratic graphs	Non Māori	56.2	15.9
	Mainstream Māori	34.3	5.2
	Te Reo	12.7	2.0
90151 (3) Solve straightforward number problems in context	Non Māori	76.2	37.3
	Mainstream Māori	58.2	18.7
	Te Reo	31.4	4.6
90152 (2) Solve right-angled triangle problems	Non Māori	67.7	29.3
	Mainstream Māori	47.2	13.6
	Te Reo	42.9	7.9
90153 (2) Use geometric reasoning to solve problems	Non Māori	75.4	29.0
	Mainstream Māori	58.4	14.2
	Te Reo	39.1	7.3
90194 (2) Calculate relative frequencies and theoretical probabilities	Non Māori	58.3	24.8
	Mainstream Māori	37.6	9.5
	Te Reo	13.3	0.6

Whika 2: Graph of NCEA Data



Discussion:

As noted above, care must be taken not to read too much into these figures. As a population, as expected, Māori students clearly achieve in these standards at lower rates than non-Māori. These results also indicate, however, that Māori-medium candidates generally achieve at lower rates than mainstream Māori candidates - the opposite result to that predicted, or at least hoped for - although, given such small numbers, attempts to quantify these disparities are futile. The strongest point concerning the Māori-medium results may be made by looking at the aggregated data across all the standards, which show that for the 1317 Pūtaiao and Pāngarau examination papers completed in the first three years, nearly three-quarters resulted in Not achieved (Whika 3 below). This is a large negative result to ignore or explain as statistically invalid. It indicates little reason for optimism that Māori-medium education has to date resulted in better academic achievement in science and mathematics, and that much work remains to be done, if greater achievement is the goal.

Whika 3: Aggregated Pūtaiao and Pāngarau NCEA Results

	No. papers	**N (%)**	**A (%)**	**M (%)**	**E (%)**
All Pūtaiao	376	291 (77.4)	82 (21.8)	3 (0.8)	0 (0)
All Pāngarau	941	693 (73.5)	210 (22.3)	38 (4.0)	0 (0)
Katoa (Total)	**1317**	**984 (74.7)**	**292 (22.2)**	**41 (3.1)**	**0 (0)**

Another suggestion from these results is that NCEA Pāngarau currently enjoys better success than NCEA Pūtaiao, a conclusion supported by my personal observations teaching in kura. Curriculum developments in Pāngarau have tended to be somewhat ahead of Pūtaiao, more cohesive, and relatively better supported. Pāngarau has the advantage that its content is more unitary, and progression is more transparent. There is also a possible link to the lower level of vocabulary-related issues in Pāngarau, since more conceptual content knowledge is carried in numerals, symbols, and diagrams.

These translated examinations do not contribute to or promote retention of traditional pre-European mātauranga Māori - a consideration which is part of the 'knowledge issue' of Māori science education. It

must be conceded therefore, that as a group, these Māori students have further underachieved in mainstream science compared with their peers, while simultaneously being denied an alternative form of secondary science education, such as might be considered particularly relevant in Pūtaiao or KKM education.

Turning to 'language issues', in the sense of supporting the language policy in KKM of 'kōrero Māori anakē' (speak Māori only), the current Pūtaiao system, including these results, contributes to status planning for te reo Māori, by extending the domain of use of Māori to include the senior secondary science classroom. The vocabulary lists compiled in the process of translating these examinations have also provided the largest Māori science glossary (of approximately 4500 words) to date. This is a dubious achievement, however, since lexicon development (corpus planning) is not the intended role of national examination systems! Questions must still be asked about the **type** of language being promoted by current Pūtaiao teaching/learning discourse (Halliday, 2004), particularly in view of the poor initial results.

Very few Excellence grades could be expected in these data, statistically speaking, since in cohorts below about 25 students in size (which applies to six of the 33 Māori-medium cohorts), not even one student would be expected to gain Excellence anyway. Examining the raw data (in the Āpitihanga, p.12) shows that the Excellence numbers vary widely anyway, even for the large 'All' and 'Māori' student cohorts. The total lack of Excellence grades, nonetheless, begs the question of whether it is actually possible for Māori-medium students to gain Excellence in these examinations. This is important in view of the hierarchical nature of the questions, and therefore of the language of the questions, in these science examination papers, reflecting the philosophy of NCEA, as they intentionally change in nature, and increase in difficulty, between Achievement, Merit and Excellence. How this operates in these Science/Pūtaiao standards can be simplistically expressed as switching emphasis from 'recall/naming-' to 'interpretation/evaluation-' type questions. One possibility, therefore, is that the current system automatically excludes Te Reo candidates from Excellence (and Merit) questions, by virtue of their limited mastery of science discourse, in either English or Māori. In my experience, when the specific characteristics of science language have been discussed at all in Pūtaiao development processes, it has been only in terms of the need to find or provide kupu hou (vocabulary) relating to science topics, particularly in the secondary curriculum.

The increasingly specialised and technical discourse, which characterises senior secondary science text, results in a predominance of science neologisms in Pūtaiao text, within language structures that are rendered repetitive and inelegant by the nature of the domain, at risk of distortion or ambiguity of meaning. The resulting text is extremely difficult for *anyone* to understand. Part of this difficulty relates to the metaphorical aspects of the English language and of te reo Māori, and how they differ (Heath, 1983). In my own experience, prior knowledge of the science content is often essential in order to fully comprehend unfamiliar extended Pūtaiao text at senior curriculum levels, particularly if visual aids are lacking. One response is for the kaiako to switch to English in order to make a science teaching point, which bilingual wharekura students are then able to 'back-translate' into Māori. A great deal of emotional investment is apparent in the positions taken in this debate, and strong orthodoxy denies the use of English in kura classrooms, with the result that such practices verge on being 'undiscussable' (Young, 1989, p.163) in the current Māori-medium education debates. Clearly, this situation is unhelpful for the interests of Pūtaiao learners and teachers.

Where to from here?

There are various problems associated with neologism, and not using international science terms (Spolsky and Shohamy, 2001): a permanent position of lexicon catch-up; teacher lack of familiarity; and creating a barrier to the wider world of science discourse (Grabe and Kaplan, 1986). There is also the possibility that coining new words exhausts the (admittedly sparse) resources, human and monetary, available for consideration of language issues in Pūtaiao, resources which could be made available for more productive activities (in terms of better teaching and learning of science), if a widespread policy of borrowing, or transliterating, international science terminology were to be adopted.

The Māori-medium examination data presented above indicate a paradox exists in Pūtaiao, in that the effect being produced is the opposite of the desired outcome for Māori-medium science education. Policies and practices in support of language status planning goals have, in this case, had the unintended effect of exacerbating underachievement in science education, while simultaneously disallowing reform of the science curriculum according to the underlying principles of Kura Kaupapa Māori, and also failing to support the goal of retaining traditional Māori knowledge. This situation may be compared with a set of attitudes towards Māori that Ray (Harlow, 2005) describes as 'covert', since they contradict overtly-held positive attitudes towards the maintenance of te reo Māori (Harlow, 2005). Harlow gives several examples - the one-name fallacy ('that there is only one real name for a place, [the name it] is called when one is speaking English', p.140), an insistence on correct Māori pronunciation when speaking English, tokenism in bilingual publications, and Māori names as logos – all of which he argues indicate an underlying view of the position of Māori 'as a dependent "add-on" to English within New Zealand' (ibid). This is significant, since in Harlow's opinion these attitudes 'tend to militate against the goals ... for the status of Māori' (p.135) and send Māori down a similar path to extinction as Irish – a badge of identity, but not a language of 'normal discourse' (p.144).

Similarly, the overt attitude towards Māori-medium science education is an aim to ensure better academic achievement, while also protecting the future of Māori language and knowledge. The unacknowledged i.e. 'covert' effects of Pūtaiao to the contrary are indicated above. By virtue of the system and policy environment in which it has emerged, Pūtaiao in effect operates as a 'dependent add-on' to Science. Moreover, Harlow's phrase 'opaque and metaphorical' is apt for some of the Māori science vocabulary which has been developed, and the resulting Pūtaiao texts. Such vocabulary and texts perhaps form part of the 'badge of identity' of kura, rather than elements of authentic Māori discourse (Crombie and Houia-Roberts, 2001). This lends weight to a 'suspicion' (following Harlow, 2005) that identity politics and educational imperatives tend to counteract each other, in the language and curriculum debates within current discourses of Pūtaiao.

4: Kaupapa Māori Science education

To see the issue of Māori science curriculum as one of science/English/Pākehā versus mātauranga/te reo/Māori is to seriously oversimplify the debates, and to veer towards unconstructive 'oppositional politics' (McLaren, 1995). What is needed is a Māori way of 'how' to regard science that moves beyond an understanding of the 'what' of Māori science either as traditional knowledge, or as translated modern science (McKinley, 1995). Developing Pūtaiao curriculum along these lines (as a Kaupapa Māori science curriculum) would aim to produce a local, critical science curriculum, not based on 'indigenous' or 'postmodern' science, but informed by multicultural and postcolonial analyses of society and education, and sociology of science (Doll, 1993). One way to do this is to re-articulate the notion of Pūtaiao education as **Kaupapa Māori Science** education, based on a notion of science education with the following characteristics:

- a critical perspective on W-science - a critical science for Aotearoa New Zealand, which remains aware of its own limitations, and includes history and philosophy of science, while rejecting 'final form' (Duschl, 1990) and other scientistic representations of science in the curriculum;
- an awareness of processes of cultural hybridity and interdependence, and of science as a product of (multi)cultural knowledge, while rejecting the 'windowless monad' notion of culture (Moody-Adams, 1997);
- an acknowledgement of the validity of science knowledge found within mātauranga Māori, i.e. a pluralist perspective on knowledge while rejecting radical epistemological relativism (Siegel, 2006);

- an awareness of the importance of Māori philosophy, principles and practices including language and culture;
- an awareness of the position of the Pūtaiao curriculum within language shift and change processes, and of the balance between aims in language planning and in science education; and
- a political stance mandated by the Treaty of Waitangi to underpin its legitimacy and entitlement to state resources (Smith, 1997).

Critical theorists of education have emphasised (Young, 1989), however, that in order to critique a discipline it is first necessary to 'master' it. What this means in each of the domains of the curriculum is likely to vary widely. For Pūtaiao, I believe it is valid to ask if construction of a parallel science lexicon past Level 4-5 is the best way to help achieve the required increase in participation of Māori in the world of science. If not, much work for Pūtaiao educators still remains to be done, as this section has attempted to indicate. For other curriculum areas, other considerations are likely to lead to different questions they would like to address in their development processes.

We want, therefore, to avoid, while developing the capacity to critique, scientism and science ideology, but not to do away with science. This approach can be characterised as follows:

1. The best possible W-science education in a strong kaupapa Māori school environment, cognisant of the need to 'master' the discipline in order to critique it, while continuing to support Māori student identity as the tūranga (standpoint) of critique.
2. Inclusion of the critical perspective where possible throughout the curriculum. Exploration of the possibility of using narrative pedagogy for teaching about the nature of science (Barker, 2006), including the history and philosophy of science (not science content - see Gilbert, Hipkins et al., 2005).
3. Recognition of the requirement to develop a science register of te reo Māori, in order to express complex science situations, processes, etc, with the required precision and unambiguity - going beyond that of the current 'word-list' approach to lexical expansion in Pūtaiao.
4. Relaxation of the 'Māori-only' language policy for senior science classes, possibly by viewing te reo Pūtaiao (the language of science) as international rather than 'English'. Such a policy follows Smith's (1995) call for an 'eclectic' approach, which directly opposes the current dominance of purism in Pūtaiao language-of-education policy.

Following the analysis of science language by Halliday (2004), I surmise that, for a number of reasons, including the influence of language purism (Harlow, 2003), the characteristic science discourse associated with senior secondary science curricula has not yet emerged in Pūtaiao, or Māori-medium science, classrooms. This suggests the question of whether, or when, such discourse will develop, if current policy trajectories continue unchanged. This paper has attempted to scope the field of Pūtaiao education and indicate a number of future research directions that might be followed. While not claiming to have laid any one of these areas to rest, the ideas about Pūtaiao as 'Kaupapa Māori Science education' presented in my earlier paper (Stewart, 2005) have been updated and extended. To what extent these ideas bear fruit remains to be seen.

Āpitihanga/Appendix

NZQA Data:

Year	Type of candidate	Standard Number	Count N	Count A	Count M	Count E
2002	All	90147	13634	11511	11136	1988
2003	All	90147	19576	12873	4974	1713
2004	All	90147	14301	14382	10223	570
2002	Māori	90147	2206	1276	627	54
2003	Māori	90147	2693	908	171	34
2004	Māori	90147	2627	1452	465	5
2002	Translated	90147	34	4	1	0
2003	Translated	90147	46	7	1	0
2004	Translated	90147	47	18	2	0
2002	All	90148	15391	17530	3746	1201
2003	All	90148	18660	10794	8528	494
2004	All	90148	18854	16425	1789	1163
2002	Māori	90148	2281	1556	179	36
2003	Māori	90148	2629	777	335	4
2004	Māori	90148	3108	1187	48	20
2002	Translated	90148	34	5	0	0
2003	Translated	90148	41	7	3	0
2004	Translated	90148	56	4	0	0
2002	All	90151	9230	17150	12810	1288
2003	All	90151	13247	14687	8829	3897
2004	All	90151	9082	15590	15283	853
2002	Māori	90151	1708	1977	845	29
2003	Māori	90151	2079	1457	492	113
2004	Māori	90151	1936	1902	1020	22
2002	Translated	90151	27	10	2	0
2003	Translated	90151	41	21	3	0
2004	Translated	90151	52	16	3	0
2002	All	90152	11837	15508	7557	5110
2003	All	90152	14500	12455	13465	96
2004	All	90152	15505	17764	6487	655

Year	Type of candidate	Standard Number	Count N	Count A	Count M	Count E
2002	Māori	90152	2047	1681	488	230
2003	Māori	90152	2214	1151	731	1
2004	Māori	90152	2783	1642	345	8
2002	Translated	90152	23	10	4	0
2003	Translated	90152	14	15	7	0
2004	Translated	90152	43	24	0	0
2002	All	90153	10487	12182	13299	1662
2003	All	90153	11925	18784	6026	818
2004	All	90153	6735	20057	7713	682
2002	Māori	90153	1778	1342	900	62
2003	Māori	90153	1797	1640	276	8
2004	Māori	90153	1379	2223	409	11
2002	Translated	90153	24	10	2	0
2003	Translated	90153	34	18	5	0
2004	Translated	90153	34	20	4	0
2002	All	90188	13785	9826	3107	474
2003	All	90188	11767	10736	3552	1243
2004	All	90188	12587	11582	2230	191
2002	Māori	90188	2029	766	138	14
2003	Māori	90188	1693	881	170	53
2004	Māori	90188	2050	980	88	4
2002	Translated	90188	12	0	0	0
2003	Translated	90188	18	10	1	0
2004	Translated	90188	34	5	0	0
2002	All	90189	11373	14182	7864	2011
2003	All	90189	13535	13083	8551	1347
2004	All	90189	15785	11957	4779	1304
2002	Māori	90189	1801	1335	382	45
2003	Māori	90189	1962	1082	368	25
2004	Māori	90189	2513	1027	217	36
2002	Translated	90189	13	0	0	0
2003	Translated	90189	22	8	0	0

Year	Type of candidate	Standard Number	Count N	Count A	Count M	Count E
2004	Translated	90189	34	4	0	0
2002	All	90190	15231	11489	1960	53
2003	All	90190	8494	14218	1682	59
2004	All	90190	10806	8549	2879	1226
2002	Māori	90190	2226	821	78	2
2003	Māori	90190	1285	1166	72	1
2004	Māori	90190	1740	749	159	48
2002	Translated	90190	11	2	0	0
2003	Translated	90190	26	7	0	0
2004	Translated	90190	22	5	2	0
2002	All	90191	8916	19442	4343	767
2003	All	90191	17382	12740	3761	826
2004	All	90191	9289	17563	5712	810
2002	Māori	90191	1422	1828	199	20
2003	Māori	90191	2350	830	143	31
2004	Māori	90191	1710	1752	258	11
2002	Translated	90191	6	7	0	0
2003	Translated	90191	22	6	0	0
2004	Translated	90191	22	12	0	0
2002	All	90192	7558	12341	4046	310
2003	All	90192	7697	10575	3248	575
2004	All	90192	6655	9519	1223	569
2002	Māori	90192	1147	1127	195	6
2003	Māori	90192	1064	894	142	18
2004	Māori	90192	1087	814	50	17
2002	Translated	90192	11	2	0	0
2003	Translated	90192	16	6	0	0
2004	Translated	90192	22	8	0	0
2002	All	90194	18902	13025	5132	1476
2003	All	90194	15025	12735	9915	996
2004	All	90194	16758	12036	7876	1272
2002	Māori	90194	2800	1172	237	34

Year	Type of candidate	Standard Number	Count N	Count A	Count M	Count E
2003	Māori	90194	2214	1157	484	13
2004	Māori	90194	2857	1171	369	39
2002	Translated	90194	37	2	0	0
2003	Translated	90194	48	11	0	0
2004	Translated	90194	58	8	1	0

Rārangi Pukapuka/References

Aikenhead, G. (2000) Renegotiating The Culture of School Science, in: R. Millar, J. Leach and J. Osborne (eds.), *Improving Science Education - the contribution of research* (Buckingham, Philadelphia, Open University Press) pp. 245-264.

Baker, C. (1993) Bilingual Education in Wales, in: H. Baetens Beardsmore (ed.), *European Models of Bilingual Education* (Clevedon, Multilingual Matters) p. 92.

Bell, B. (1995) *Responses to 'Challenging NZ Science Education' by Michael R. Matthews* (Hamilton, Centre for Science, Mathematics and Technology Education Research, University of Waikato).

Bell, B., A. Jones, et al. (1995) The development of the recent national New Zealand science curriculum, *SAME papers 1995* (Hamilton, CSMTER) pp. 3-44.

Blades, D. W. (2006) Levinas and an Ethics for Science Education, *Educational Philosophy and Theory*, 38:5, pp. 647-664.

Boyd, R. N. (2001) Reference, (In)commensurability and Meanings: Some (Perhaps) Unanticipated Complexities, in: P. Hoyningen-Huene and H. Sankey, *Incommensurability and related matters* (Dordrecht, Kluwer) pp. 1-63.

Carson, R. N. (1997) Why Science Education Alone is Not Enough, *Interchange*, 28:2 & 3, pp.109-120.

Charlesworth, M. (1982) *Science, Non-science & Pseudo-science* (Burwood, Vic, Deakin University Press).

Crombie, W. and N. Houia-Roberts (2001) The Rhetorical Organisation of Discourse: Language Revitalisation and the Question of Authenticity, *Journal of Maori and Pacific Development,* 2:2, pp. 57-73.

Doll, W. E. (1993) *A Post-modern Perspective on Curriculum* (New York and London, Teachers College Press).

Duschl, R. A. (1990) *Restructuring school science: The importance of theories and their development* (New York, Teachers College Press).

Gilbert, J., R. Hipkins, et al. (2005) *Faction or fiction: Using narrative pedagogy in school science education*, Redesigning Pedagogy: Research, Policy, Practice (Nanyang University Institute of Education, Singapore).

Grabe, W. and R. B. Kaplan (1986) Science, technology, language, and information: implications for language and language-in -education planning, *International Journal for the Sociology of Language*, 59, pp. 47-71.

Gregory, A. (2001) *Eureka! The birth of science* (Cambridge, Icon Books).

Haigh, M. (1995) The Achievement Initiative in Science: developing Science in the New Zealand Curriculum, *SAMEpapers 1995* (Hamilton, CSMTER Publications) pp. 45-74.

Halliday, M. A. K. (2004) Language and the Reshaping of Human Experience (1995), in: J. J. Webster, *The Language of Science*, pp. 7-23.

Halliday, M. A. K. (2004) *The Language of Science* (London and New York, Continuum).

Hanson, N. R. (1958) *Patterns of discovery: An inquiry into the conceptual foundations of science* (Cambridge, Cambridge University Press).

Harlow, R. (2003) Issues in Māori language planning and revitalization, *Journal of Maori and Pacific Development*, 4:1, pp. 32-43.

Harlow, R. (2005) Covert attitudes to Māori, *International Journal for the Sociology of Language*, 172, pp. 133-147.

Heath, S. B. (1983) *Ways with Words: Language, life and work in communities and classrooms* (New York, Cambridge University Press).

Heidegger, M. (1977) *The Question Concerning Technology and other essays* (New York, Harper Torchbooks).

Hersh, R. (1994) Fresh breeezes in the Philosophy of Mathematics, in: P. Ernest (ed.) *Mathematics, Education and Philosophy* (London, Falmer Press) 3, pp. 11-20.

Hodson, D. (1999) Critical Multiculturalism in Science and Technology Education, Critical Multiculturalism: Rethinking Multicultural and Antiracist Education (Falmer Press) pp. 216-244.

Irwin, K. (1999) Māori Education Policy 1989-1998: Lampooning it up!, in: M. Thrupp (ed.), *A Decade of Reform in New Zealand Education: Where to Now?* (Hamilton, School of Education, University of Waikato) pp. 66-76.

Irzik, G. (2001) Universalism, Multiculturalism, and Science Education, *Science Education*, 85:1, pp. 71-73.

Jones, D. V. and M. Martin-Jones (2004) Bilingual Education and Language Revitalization in Wales: Past Achievement and Current Issues, in: J. W. Tollefson and A. B. M. Tsui. Mahwah (ed.), *Medium of Instruction Policies* (Lawrence Erlbaum Associates), pp. 43-70.

Kawasaki, K. (2002) A Cross-Cultural Comparison of English and Japanese Linguistic Assumptions Influencing Pupils' Learning of Science, *Canadian and International Education*, 31:1, pp. 19-51.

Lacey, H. (1999) *Is Science Value Free? Values and Scientific Understanding* (London and New York, Routledge).

Lacey, H. (2001) Incommensurability and "Multicultural Science", in: P. Hoyningen-Huene and H. Sankey (ed.), *Incommensurability and related matters* (Dordrecht, Kluwer) pp. 225-239.

Loving, C. C. (1997) From the Summit of Truth to Its Slippery Slopes: Science Education's Journey Through Positivist-Postmodern Territory, *American Educational Research Journal*, 34:3, pp. 421-452.

M.O.E. (1996) Pütaiao i roto i te Marautanga o Aotearoa (Wellington, Learning Media).

Matthews, M. (1994) *Science Teaching: The Role of History and Philosophy of Science* (New York, Routledge).

Matthews, M. (1995) *Challenging NZ Science Education* (Palmerston North, The Dunmore Press Ltd).

McKinley, E. (1995) A Power/Knowledge Nexus: Writing a Science Curriculum in Māori, *Science Education* (Hamilton, University of Waikato).

McKinley, E. (1997) Māori and science education: participation, aspirations and school curricula, in: B. Bell and R. Baker (eds.), *Developing the Science Curriculum in Aotearoa New Zealand* (Auckland, Longman) pp. 213-226.

McKinley, E. (2005) Locating the Global, *International Journal of Science Education*, 27:2.

McKinley, E. (2007) Postcolonialism, Indigenous Students, and Science Education, in: S. K. Abell and N. G. Lederman, *Handbook of Research in Science Education* (Mahwah and London, Lawrence Erlbaum Associates) pp. 199-226.

McKinley, E., G. Stewart, et al. (2004) Māori Students in Science and Mathematics: Junior programmes in secondary schools, *SET* 2004:3, pp. 9-13.

McLaren, P. (1995) *Critical Pedagogy and Predatory Culture: Oppositional Politics in a Postmodern Era* (London and New York, Routledge).

McMillan, B. (1995) Making sense of the debate about the science curriculum document, *SAMEpapers*, 1995, pp. 95-113.

McPherson Waiti, P. (1990) A Māori Person's Viewpoint on the Education of Māori Children and in Particular, Science Education, *SAMEpapers 1990* (Hamilton, Centre for Science and Mathematics Education Research, University of Waikato) pp. 177-201.

Moody-Adams, M. M. (1997) *Fieldwork in Familiar Places* (Cambridge MA and London, Harvard University Press).

MORST (1995) The Interface Between Mātauranga Māori and Mainstream Science (Wellington, Ministry of Research, Science and Technology) p. 21.

Murray, S. (2007) Achievement at Māori immersion and bilingual schools: Update for 2005 results (Wellington, Demographic and Statistical Analysis Unit (DSAU), Ministry of Education) p. 17.

Peters, M. (1993) Post-modern Science in Aotearoa? Conservation, Cosmology and Critique, *Research Unit for Māori Education, University of Auckland* (Auckland).

Peters, M., W. Hope, et al., eds. (1996) *Critical Theory, Poststructuralism & the Social Context* (Pamerston North, Dunmore Press).

Roberts, M. (1998) Indigenous knowledge and western science: perspectives from the Pacific, in: D. Hodson. (ed.) Science and Technology Education and Ethnicity: an Aotearoa New Zealand Perspective (Wellington, The Royal Society of New Zealand) pp. 59-75.

Siegel, H. (2006) Epistemological Diversity and Education Research: Much Ado About Nothing Much?, *Educational Researcher*, 35:2, pp. 3-12.

Simon, K. H. (2003) Searching for synergy: Māori/indigenous and scientific conservatory values - the affinity proposition, *Journal of Maori and Pacific Development*, 4:1, pp. 44-58.

Smith, G. H. (1995) Falling through the cracks of the constructivism debate: the neglect of the Māori crisis within science education, *ACCESS - Critical Perspectives on Cultural and Policy Studies in Education*, 31:2, pp. 103-121.

Smith, G. H. (1997) Kaupapa Māori as transformative praxis, Education (Auckland, University of Auckland).

Spivak, G. C. (1987) In Other Worlds: Essays in cultural politics (Methuen).

Spolsky, B. and Shohamy, E. (1999) *The Languages of Israel* (Clevedon, Multilingual Matters Ltd).

Spolsky, B. and Shohamy, E. (2001) The Penetration of English as Language of Science and Technology into the Israeli Linguistic Repertoire: A Preliminary Enquiry, in: U. Ammon (ed.), *The Dominance of English as a Language of Science* (Berlin and New York, Mouton De Gruyer) p. 84.

Stanley, W. B. and N. W. Brickhouse (1994) Multiculturalism, universalism and science education, *Science Education*, 78, pp. 387-398.

Stewart, G. (2005) Māori in the science curriculum: developments and possibilities, *Educational Philosophy and Theory***,** 37:6, pp. 851-870.

Tymoczko, T. (1994) Structuralism and Post-modernism in the Philosophy of Mathematics, in: P. Ernest. (ed.) *Mathematics, Education and Philosophy* (London, Falmer Press) pp. 49-55.

Williams, D. (2001) *Crown Policy Affecting Māori Knowledge Systems and Cultural Practices* (Wellington, Waitangi Tribunal).

Young, R. E. (1989) *A critical theory of education: Habermas and our children's future* (New York, Harvester Wheatsheaf).