Reframing the Essentials Skills:
Implications for and from the Science Curriculum

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Introduction

Our Ministry of Education is currently taking stock (Ministry of Education, 2002) of its Curriculum Framework, which has served New Zealand since 1993. One element of the Curriculum Framework which is under review is the eight Essential Skills (Ministry of Education, 1993a, p.5) namely: communication skills; numeracy skills; information skills; problem-solving skills; self-management and competitive skills; social and co-operative skills; physical skills; and work and study skills. A proposal exists (Brewerton, 2004) to replace these, in any revision of the Framework, with a number of Essential Competencies. Proposed competencies, if accepted, would need to provide a suitable platform for education in each of the seven Essential Learning Areas (technology, social sciences, etc.) that a new Curriculum Framework would subsume. Conversely, each Essential Learning Area should have the capacity to contribute to the competencies listed in the Framework.

This paper considers how well the catalogue of **essential competencies** critiqued by Brewerton (the so-called 'DeSeCo' competencies, see below) might resonate with appropriate **science competencies** in any future revision of *Science in the New Zealand Curriculum* (Ministry of Education, 1993b).

The 'DeSeCo' Essential Competencies – Commentaries and Adaptations

Our task was framed in the context of a number of existing formulations of competencies, most foundational of which was the 'DeSeCo' Essential Competencies. As presented by Brewerton (Figure 1), these were an outcome of the Organisation for Economic Co-operation and Development (OECD) 'Defining and Selecting Key Competencies' project (DeSeCo). In adapting them for the New Zealand context, Brewerton (2004) suggested (Figure 2) some hierarchical modifications to the cross-cutting group of competencies, but left the other three groups of competencies substantially unaltered. Specifically (and significantly for us), Brewerton advocated subsuming the whole cross-cutting group under the heading 'Thinking'. This was intended "to make the nature of this group of competencies … the only one to have no title … more easily understood" (page 42).

A subsequent Ministry of Education briefing paper (Ministry of Education, 2004) also considered the 'DeSeCo' essential competencies. It proposed five, rather than four, so-called clusters of competencies, with titles as follows:

Thinking (Cross-cutting) ***Creativity*** ***Metacognition*** Including Holistic/integrated Approach Critical thinking Learning to learn Self-awareness Judgement	**Interacting in social groups, both heterogeneous and homogenous** Ability to relate well to others Ability to cooperate Ability to manage and resolve conflict Ability to support, fulfill responsibilities and contribute to others **Acting autonomously** Ability to identify, assert and take action regarding one's individual and collective rights, interests, responsibilities, limits and needs Ability to form and conduct life plans and personal projects Ability to act within the big picture/larger context **Using tools interactively** Ability to use language, symbols and text interactively Ability to use knowledge and information interactively Ability to use (new) technology interactively

Figure 1: The 'DeSeCo' competencies

Thinking *(Cross-cutting)* *Creativity* *Metacognition* Including Holistic/integrated Approach Critical thinking *Learning to learn* *Self-awareness* *Judgement*	***Operating*** **in social groups, both heterogeneous and *homogenous*** Ability to relate well to others Ability to co-operate Ability to manage and resolve conflict *Ability to assert and defend rights and responsibilities* *Ability to support, fulfil responsibilities and contribute to others* **Acting autonomously** Ability to *identify and take action regarding one's interests, limits and needs* Ability to form and conduct life plans and personal projects Ability to act within the big picture/larger context **Using tools interactively** Ability to use language, symbols and text interactively Ability to use knowledge and information interactively Ability to use (new) technology interactively

Figure 2: Brewerton's (2004) proposal for a set of Framework-level essential competencies

- Thinking (although not described as ‘cross-cutting’);
- Relating and Contributing (equivalent to Brewerton’s ‘Operating in Social Groups Both Heterogeneous and Homogeneous’);
- Managing Self (compare ‘Acting Autonomously’);
- Making Meaning (compare ‘Using Tools Interactively’); and, as an addition,
- Belonging (comprising ‘Engagement in the Classroom’ and ‘Belonging Beyond the Classroom’).

Actually, prior to debates about the ‘DeSeCo’ competencies, the Stocktake document had already proposed five clusters of skills (Ministry of Education, 2002, page 29). These, when their order of presentation is tumbled, are broadly similar to the five clusters listed above from Ministry of Education (2004). The Stocktake categories are:

- Creative and innovative thinking
- Participation and contribution in communities
- Reflecting on learning and developing self-knowledge
- Making meaning from information
- Relating to other people.

Carr (2004) found that these five categories, applicable to the schools sector, could be quite readily aligned with the strands in the *Te Whariki* document, which is the basis of early childhood education.

Competencies and Science Education - Eight Guiding Principles

In approaching this task, we generated eight guiding principles:

1. *Competencies are broader than skills.*

   Brewerton (2004, p.2), with ‘DeSeCo’, defines ‘competencies’ as being at a very generic level: “includ(ing) skills, knowledge, attitudes and values needed to meet the demands of a task”, i.e. ‘competencies’ very much subsume ‘skills’. Because of this, ‘competencies’ may not simply be inserted into the structure of the science curriculum where ‘skills’ were formally located. In the science education literature ‘skills’ have been more frequently discussed and defined (e.g. Watts, 1991; Hudson, 1994) than ‘competencies’, but especially in recent years, large-scale surveys of the science education (e.g. Fraser and Tobin, 1998) have not been inclined to consider science skills in isolation from other elements of learning.

2. *Competencies can be very closely related to aims.*

   We consider that the words “to meet the demands of a task” are highly significant. We interpret this as saying that the competencies which teachers, learners and society at large need “to meet the demands of a task” can only be determined when these stakeholders have previously defined the task. At the level of science curriculum, the outcomes of this process of “defining the task” become encapsulated in statements like the present General Aims of Science Education in

Science in the New Zealand Curriculum (Ministry of Education, 1993b). Put simply, asking what competencies are needed for science education is only a meaningful question if one is clear what purposes one wishes to achieve in science education. Competencies, then, are seen by us as the human faculties needed to put aims (or purposes) into practice.

3. *Competencies can be very closely related to values.*

Values, too, are a key part of this overarching mix: "The revised values should link to the purposes, essential skills and attitudes and higher order thinking in the essential learning areas of the New Zealand curriculum and (the Framework)" (Ministry of Education, 2002, clause 134). However, Keown (2001) considers that the present Framework "… does not adequately address values education" (p.19) and that " … while there are worthy values goals in broad general terms (these) are not developed in enough detail to provide curriculum writers and teachers with enough background or advice to actually achieve these intentions" (p.7). Keown's analysis of the seven Essential Learning Area curriculum documents on five criteria gives *Science in the New Zealand Curriculum* a middle ranking, well behind Health and Physical Education and Social Studies, but well above Mathematics.

4. *Teachers of science need a science curriculum document that prominently draws attention to the essential competencies which would be listed in a new curriculum framework.*

The apparent lack of impact of the eight Essential Skills listed in the present Curriculum Framework on the thinking and practice of teachers of science over the last ten years bears this out (Baker, 1999). This is hardly surprising. In *Science in the New Zealand Curriculum* the Framework's Essential Skills appeared only in Appendix 2 (pages 128-134) and they apparently played no part in shaping *Science in the New Zealand Curriculum*. The discussion in Appendix 2 reads very much like a justification in hindsight.

5. *It is essential to define science competencies (at the level of the New Zealand science curriculum) which can be clearly seen to resonate with essential competencies (at the curriculum framework level).*

Even when essential competencies are prominently highlighted in a science curriculum document, we believe that it is essential that teachers of science be shown how these can be translated into science competencies. This process of seeding in the essential competencies, so that they ramify through the whole of a revised *Science in the New Zealand Curriculum* and can be related to all the day-to-day activities of science teaching is, on our view, fundamental.

6. Potential for two-way transfer of competencies, i.e. from generic to specific and vice versa, needs to be transparent.

The brief for the writing of this paper was couched in terms of enabling appropriate *downward* transferability (Brewerton, 2004, p.26) of essential competencies from the Framework level to the science curriculum level. We also believe that it is equally important to facilitate *upward* transfer of competencies. That is why we have called this paper "… implications for and from (sic) the Science Curriculum". We ould emphasise the importance of upward transfer of science competencies, not only from the science curriculum level, but also from the whole understorey of science classroom activities. From the teachers' point of view, these learner competencies are selected at the "What do I do on Monday?" level (Holt, 1970). These specific competencies for learners are traditionally almost never mentioned in science curricula but they are set up whenever teachers make decisions about lesson plans and unit plans, choose an appropriate specific pedagogy, or select what they hope are suitable activities and apparatus. Concerning these specific competencies and the possibility of upward transfer, Hodson (1993) concluded severely but - in our view, laudably - that: "… only those skills should be taught that are of value in pursuit of other learning … When successful engagement in an experiment requires a skill that children will not need again … alternatives should be found such as pre-assembly of apparatus, teacher demonstration, computer simulation, etc.".

7. Any formulation of competencies in education at large, and in science education in particular, needs to take account of the literature on current social trends, and of projections about the world of the future.

We consider that there are huge implications for the formulation of essential competencies arising from the six Future Focussed Themes in the Stocktake (Ministry of Education, 2002, p.33-34), namely: social cohesion; citizenship; education for a sustainable future; bicultural and multicultural awareness; enterprise and innovation; and, critical literacy. Concerning science education, Hipkins *et al.* (2002) offered a comprehensive discussion of what literature suggests might emerge in New Zealand from debates around the notion of 'scientific literacy' (chapter seven), and from a focus on the social and cultural aspects of science education (chapters eight, nine and ten). The whole emerging tendency to construe learning at large in socio-cultural terms (Hipkins, Barker and Bolstad, 2004), together with Lee's (1997) contention that "when students' language and cultural experiences are in conflict with scientific practices, when they are forced to choose, (they) may avoid learning science" have, we believe, huge significance for the formulation of competencies. From this viewpoint, competencies related to who one is (i.e., one's very being) - which is a much wider matter, even, than as what one knows - cross-cut all learning, and science learning in particular (Parker and Goicoechea, 2000).

8. *Any formulation of competencies in science education, without reference to any assumptions about the structure of a future science curriculum document, would contribute very little to the debate.*

   Framing competencies that will effectively seed into, and ramify through, a future science curriculum (see principle 5, above) requires assumptions. We assume that a future New Zealand science curriculum will contain the present six-strand structure, but that the scope and contents of the strands, especially the integrating strands, may be quite radically different. For reasons discussed in Hipkins and Barker (2002), the present integrating strand “Making Sense of the Nature of Science and its Relationship to Technology” may be redesignated the “Nature of Science” strand. A key feature would be the clarification that this strand concerns knowledge *about* science itself, especially about the nature of science knowledge, about how scientists work, and about the place of science in society. The present integrating strand “Developing Scientific Skills and Attitudes” (sic, *Science in the New Zealand Curriculum*, p.42; not “investigative”, p.44) could be clarified as applying to students, as opposed to scientists (see above), and be substantially reworked to enumerate science competencies. ‘Attitudes’ as promised by *Science in the New Zealand Curriculum*, but not actually delivered (Hipkins and Barker, 2002), could also articulated here.

The Context for Competencies: A Revised Framework and a Revised Science Curriculum

We have contended (principle 8) that the locations and relationships of competencies in the broad structures of a revised Framework and a revised Science Curriculum are probably as important as the formulation of the competencies themselves. We therefore propose (Figure 3) a possible model that defines the context of essential competencies and science competencies. It will be noted that:

- The Framework’s essential competencies are transferred directly and prominently into science curriculum (principle 4), they are located at the level of Aims of the science curriculum (principle 2), and they should be able (see below) to be translated into a set of science competencies in the body of the science curriculum (principle 5). There is a clear indication of two-way transfer between essential competencies and science competencies (principle 6); the hatched arrows indicating this are double-headed.

- The science competencies are located in the site currently occupied by ‘science skills’, but the competencies envisaged here are much broader than the present skills (principle 1). They are a catalogue of human capabilities which (as the broad unhatched arrows show) ramify through the whole science curriculum. These science competencies can be interpreted either in terms of the activities of learners in classrooms (the Contextual Strands) OR, in accordance with principle 7, in terms of scientists and citizens in society at large (the Nature of Science strand). This dual interpretation is in line with the current construction of the ‘Science IS’ website.

- Some miscellaneous features are: The Future Focussed Themes have the capacity to steer the devising of science curriculum Aims; there is provision for values to be explicit, and to resonate between the Framework and the science curriculum - where, being positioned with Aims of science education, they are clearly related to competencies (principle 3); notions of scientific literacy are located with the Aims, and are to be debated in that context; and there is an opportunity, again at the level of Aims, for the relationship between the science curriculum and the *'Puutaiao'* document to be articulated.

Essential Competencies and Science Competencies: Our Proposal

Would it be actually be possible to write, within the box labelled 'essential competencies', a formulation which *did* have appropriate "implications for and from the science curriculum"? We believe it would. Taking the various versions of *essential competencies* proposed so far at Framework level, we have chosen a combination (Figure 4) that enables, in our view, exemplification into a satisfyingly broad range of *science competencies* (Figure 5).

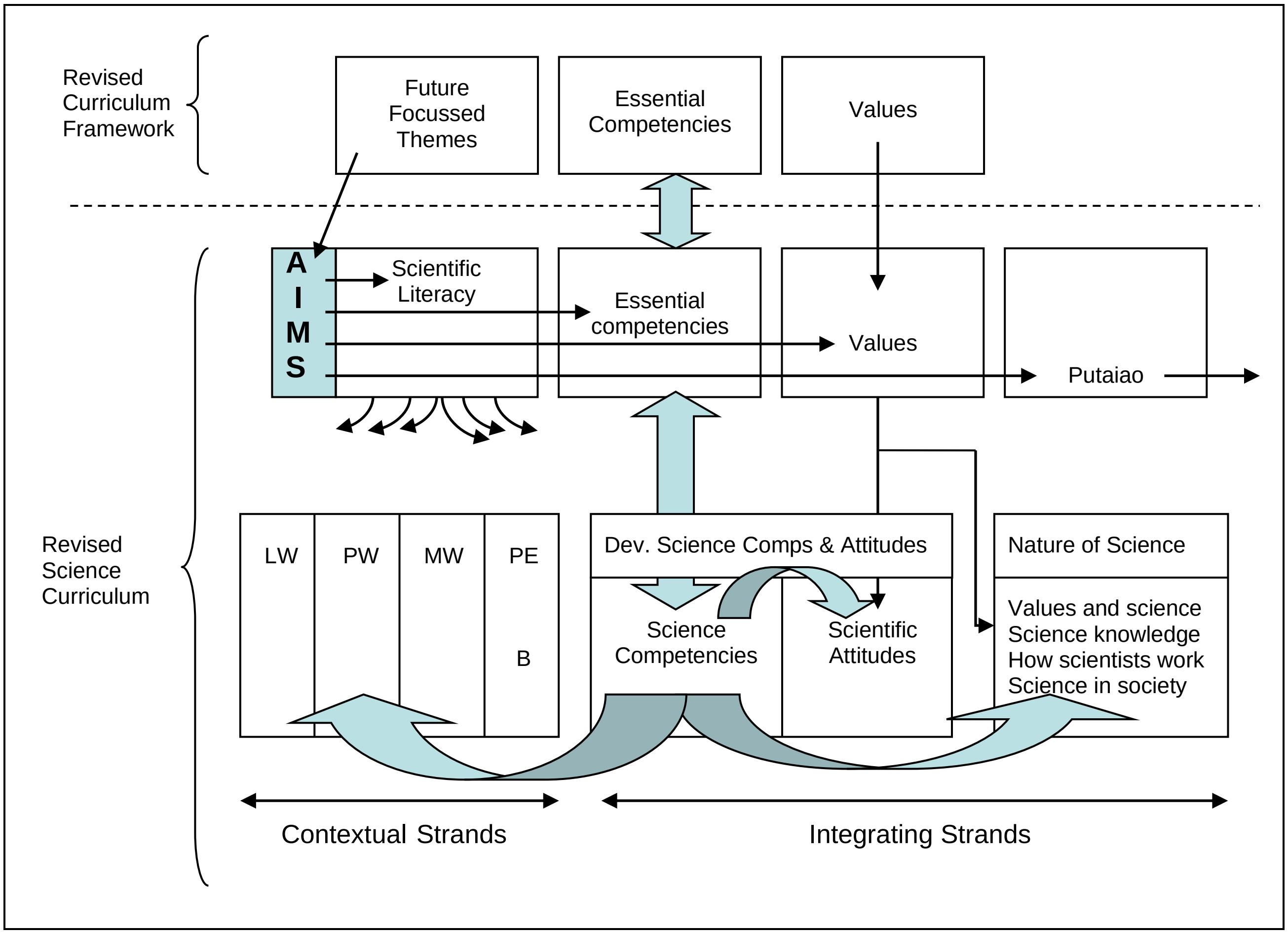

Figure 3: Translating Framework-level essential competencies into curriculum-level science competencies – a possible model.

Very specific science competencies (like those listed under 'Developing Investigative Skills and Attitudes' in *Science in the New Zealand Curriculum*, pages 44-47, are readily accommodated under the subset 'logical thinking'. The wider science competencies which are needed for a much more liberal interpretations of 'investigating', e.g. Watson, Goldsworthy and Wood-Robinson (1999) - their menu comprises classifying and identifying, fair testing, pattern seeking, investigating models, exploring and making things or developing systems - would seem to be readily available in this list of essential competencies. But going even wider, we have been at pains to argue here (principle 7) that, additionally, recent years have seen a highly significant socio-cultural turn in the orientation of science education internationally. Science competencies now need to address not just questions of thinking, but also questions of ***being*** - issues of belonging, ownership, cultural identity; and questions about the kind of world one wants to live in and, ultimately, the kind of person one wants to be. These will almost certainly be needed in the science education of the future. For example, mapping the six Future Focussed Themes on to our proposed essential competencies (Figure 4) suggested that "bicultural and multicultural awareness" and "education for a sustainable future" have a cross-cutting character which demands that 'thinking ***and being'*** would now be an appropriate overarching rubric for cross-cutting competencies.

Cross-cutting competency

THINKING AND BEING

- *Bicultural and multicultural awareness*
- *Education for a sustainable future*

Creativity

Metacognition

Including …

- Critical thinking
- Logical thinking
- Learning to learn

Belonging

Including …

- Motivation
- Connectedness

Three other competencies

RELATING AND CONTRIBUTING

- *Citizenship*
- *Social cohesion*

MANAGING SELF

MAKING MEANING

- *Enterprise and innovation*
- *Critical literacy*

Figure 4: Framework-level essential competencies - a proposal with potential for science education. *Points of major relevance of the six future focussed themes are also shown*.

Cross-cutting competency

THINKING AND BEING

- *Bicultural and multicultural awareness*
- *Education for a sustainable future*

Creativity
[Creative science involves hard wor, persistence, curiosity, playfulness, experimentation.]

Metacognition

Including …

- Critical thinking

[Interrogating science ideas to identify changes over time]
[Being aware of differences in interdisciplinary perspectives]
[Being able to recognise what skills are necessary in science]

- Logical thinking

[Focussing and planning a science investigation]
[Gathering information in science]
[Processing and interpreting science data]
[Reporting science understandings]

- Learning to learn

[Appreciating multiple perspectives of knowledge, including specific features of Western science ways of knowing the world]

Belonging

Including …

- Motivation

[Having a sense of ownership of a science environment]

- Connectedness

[Feeling part of a collaborative science enterprise]

Three other competencies

RELATING AND CONTRIBUTING

- *Citizenship*

  [Understanding interactions between scientists' work, the science community and social values]

- *Social cohesion*

  [Taking considered action related to socio-scientific issues]

MANAGING SELF

[Respecting evidence; being honest and avoiding personal bias; suspending judgement while continuing to pursue investigations]

MAKING MEANING

- *Enterprise and innovation*

  [Exploring fruitful links between science ideas, technological devices and human needs]

- *Critical literacy*

  [Using information communication technology and other technologies to build personal understandings of science]

  [Creating and critiquing scientific models]

Figure 5: Curriculum document-level science competencies - a proposal that resonates with the Framework-level essential competencies. [*Instances of science competencies that exemplify the essential competencies in Figure 4 are shown.*]

A Concluding Remark

In our view, nominating a science-appropriate catalogue of essential competencies is not so much about arguing over particular wording or formulation. What is needed is a New Zealand science education which is not, as an influential report (Millar and Osborne, 1998) on British science education found: "… increasingly irrelevant both to (students') needs and those of society". We need, therefore, to create a space for competencies that students find meaningful and motivational while they are at school, and which reflect a view of science and science education that is appropriately expansive, socially integrated and future-focussed.

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