Res Sci Educ (2011) 41:441–451
DOI 10.1007/s11165-010-9173-6

Teaching Evolution in New Zealand's Schools—Reviewing Changes in the New Zealand Science Curriculum

Alison Campbell · Kathrin Otrel-Cass

Published online: 21 April 2010

Abstract New Zealand has had a national school science curriculum for more than 80 years. In the past the evolution content of this document has varied, and has at times been strongly influenced by creationist lobby groups. The 'new' science curriculum, to be fully implemented in 2010, places much greater emphasis than before on understanding evolution, and also on teaching the nature of science. Interplay between the two can potentially improve student understanding of the culture and processes of science in general and evolutionary theory in particular. While the explicit use of the word 'evolution' highlights its significance, it is necessary to provide both resources and pedagogical guidelines to support teachers in dealing with this important topic.

Keywords Evolution · New Zealand · Curriculum · Teaching · Nature of science

Introduction

The latest iteration of New Zealand's school science curriculum was launched in November 2008, following extensive public consultation, and is expected to be fully implemented by 2010 (Ministry of Education 2007). It represents a philosophical change of direction from previous documents, with an up-front emphasis on the importance of teaching students about the nature of science. In addition, the biology 'strand' of the curriculum recognises evolution as the organising principle of modern biology, and expects that students will be exposed to concepts and ideas informed by evolutionary science from the point when they first begin school as new entrants. As such, it may be more effective in enhancing student understanding of evolution. To assess how likely this is, especially in the face of what may be a renaissance of creationism, it is necessary to review how previous curriculum documents have approached the subject of evolution.

A. Campbell
Department of Biological Sciences, University of Waikato, Hamilton, New Zealand

K. Otrel-Cass (✉)
Centre for Science & Technology Education Research, University of Waikato, Hamilton, New Zealand
e-mail: kathrino@waikato.ac.nz

Creationism in New Zealand's Classrooms

Various creationist lobby groups have long been present in New Zealand and have at times been quite effective in influencing the science curriculum. This has been well-documented by McGeorge (1992) and Numbers and Stenhouse (2000). For example, in 1871 Dunedin creationists lobbied (unsuccessfully) for the sacking of an Otago professor who had taught evolution in his university classroom. When some of the principles of evolution were included for the first time in the national science syllabus, in 1928, creationist groups managed to force the removal of any reference to human evolution from the document. And similarly, in 1947 lobby groups blocked New Zealand's Radio for Schools programme from using a BBC radio series on evolution.

Subsequently, creationism was able to find a place in New Zealand's school classrooms. Numbers and Stenhouse (2000) point out that in 1982 the then Auckland Department of Education issued a creationist textbook intended for senior biology classes. This was distributed by the Auckland College of Education's Science Resource Centre: teachers could be excused for thinking this was a reputable source of scientific information. Numbers and Stenhouse (2000: p 348) cite a spokesman for the New Zealand Education Department, who commented that "he found nothing wrong with science teachers including 'scientific creationism' in their classes, 'as long as they're presenting it as one possible explanation and not the only explanation.'" Such sentiments are still expressed today.

At the same time, the Creation Science Foundation (CSF) in Australia was expanding rapidly, so that by the 1990s it was the world's second-largest creation-science organisation. In fact, Scott and Branch (2003) point out that the largest creationist group in the United States, Answers in Genesis (AiG), is actually run by a group of Australians and New Zealanders. The views expressed by CSF and AiG have been embraced by religious conservatives in New Zealand, and also among our Maori and Pasifika communities (e.g. Peddie 1995).

As recently as 2008, a Christian lobby group has mailed teaching materials directly to the heads of science departments of every secondary school in New Zealand that promote an 'alternative theory' to evolution. These mailouts have included videos and CD ROMS of *Icons of evolution* and *The privileged planet*, both of which are informed by and promote an Intelligent Design perspective on the origins of life. There is no systematic process for vetting this material, nor has it passed through a system of peer review. Questioned about the propriety of the group's actions, a spokesman for the Ministry of Education said that "parents had a right to withdraw children from religious education" (Nichols 2008)—failing to recognise that the resources were not intended for use in religious instruction classes.

Evolution in the New Zealand Science Curriculum

Since the end of the 19th century there have been public debates in New Zealand that influenced the position of evolution in the science curriculum. In his review on evolution in the New Zealand curriculum 1900–1950, McGeorge (1992) found that as long as the term 'evolution' was not used in the teaching syllabus it did not seem to present a problem. The explicit inclusion of the term in the senior student syllabus, in 1928, promptly sparked protests that calmed down only when the Department of Education made it clear that 'evolution' referred only to 'physical geography or natural theology' (p.208). McGeorge concluded that subsequently there were no major problems associated with the teaching of evolution, apart from the occasional debate, simply because it did "not appear as a specific topic in school biology until Form 7 [equivalent to year 13]" (p.217) and thus did not attract much attention. He cites a member of the New Zealand Creation Literature Society, who said that "if evolution were dealt with more widely they would push for an even-handed treatment of both evolution and creationism" (p. 217).

The 1993 science curriculum (Ministry of Education 1993) did not move much from this position. Evolution gains an explicit mention only in the level 8 (living world) section of the science curriculum, which students encounter in their final year of secondary school (year 13). In fact the 1993 document, while giving evolution as a sample learning context at level 8 (p.68), provides much room for individual interpretation: for a possible learning experience it suggests that students "could hold a debate about evolution and critically evaluate *the theories* relating to this biological issue", and that their learning could be assessed by the "ability to select appropriate information …which explore[s] the *current theories* about evolution" (p.69) (emphasis added).

This wording is ambiguous and effectively offers a loophole that allows teaching of 'alternative' views in the classroom by implying that there is more than one scientific theory explaining the origins and diversity of life. Thus in 1995 it was possible to say "… in this country [New Zealand] some private schools, and some teachers within the state school system and home schooling systems, continue to teach creationism and debunk evolution" (Peddie 1995). In 2003 the Education Gazette carried an advertisement for a workshop on intelligent design. Aimed at teachers and parents, this event included the Discovery Institute's William Dembski on its list of speakers, and claimed to be 'an excellent learning opportunity that offers both a professional development opportunity and a fresh look at some knotty problems in science and biology' (Education Gazette 22 August 2003).

In 2006 the Royal Society (NZ) wrote to the Ministry, expressing their concern about the increasing prominence of the form of creationism known as intelligent design and the opportunities for it to be taught within the science classroom. A Ministry spokesman responded that "it is not the intention of the science curriculum that the theory of evolution should be taught as the only way of explaining the complexity and diversity of life on Earth" (P. Spratt, personal communication, 2006), adding that—within existing curriculum guidelines—schools are free to decide their own approaches to theories dealing with the origins of life. The statement continued: "The science curriculum does not require evolution to be taught as an uncontested fact at any level. The theory of evolution cannot be replicated in a laboratory and there are some phenomena that aren't well explained by it".

However, all this is set to change with the implementation of the new curriculum. Without any doubt the most notable difference between the 1993 document and the version published in 2007 is the explicit recognition of evolution as the overarching organising theme within the living world (biology) strand of the science curriculum, at all curriculum levels, accompanied by the overt expectation that students at all levels will develop an enhanced understanding of the nature of science. Thus, for the living world strand the 2007 New Zealand curriculum document states that students should "develop an understanding of the diversity of life and life processes, of where and how life has evolved, and of evolution as the link between life processes and ecology…" (Ministry of Education 2007: 28). Table 1 compares the two documents in terms of when evolution and related concepts are introduced in the science curriculum. Levels 1–8 represent the learning levels, from new entrants at level 1 to students in year 12 or 13—their final school years—at level 8.

While the 1993 document introduces the concepts of extinction (level 3), environmental changes and plant and animal responses (level 4), adaptation (level 5), inheritance (level 5), genetics (levels 5,6,7), and genetic variation (level 7), it mentions evolution specifically, and origin of species in particular, at level 8 only. The 2007 document in contrast starts at

Table 1 Evolution in the New Zealand science curriculum in 1993 and 2007

Level	Reference to evolution in the 1993 curriculum document (MoE 1993).	Reference to evolution in the 2007 curriculum document (MoE 2007).
1	*Under achievement objectives:*	*Under Evolution:*
	Group the living world according to some of its attributes.	Recognise that there are lots of different living things in the world and that they can be grouped in different ways.
	Investigate and describe changes in a particular plant or animal over time.	Explain how we know that some living things from the past are now extinct.
2	*Under achievement objectives:*	*Under Evolution:*
	Investigate responses of plants or animals, including people, to environmental changes in their habitat.	Same as above.
3	*Under achievement objectives:*	*Under Evolution:*
	Research and describe how some species have become extinct or are endangered.	Begin to group plants, animals and other living things into science based classifications.
		Explore how the groups of living things we have in the world have changed over long periods of time and appreciate that some living things in New Zealand are quite different from living things in other areas of the world.
4	*Under achievement objectives:*	*Under Evolution:*
	Investigate and classify closely related living things on the basis of easily observable features.	Same as above.
	Investigate and describe special features of animals or plants which help survival into the next generation.	
	Investigate and describe patterns in the variability of a visible physical feature found within a species.	
5	*Under achievement objectives:*	*Under Evolution:*
	Investigate and describe structural, physiological, and behavioural adaptations which ensure the survival of animals and flowering plants in their environment.	Describe the basic processes by which genetic information is passed from one generation to the next.
	Investigate patterns in the inheritance of genetically controlled characteristics and explain the importance of variation within a changing environment.	
6	*Under achievement objectives:*	*Under Evolution:*
	(a) Describe cell division and explain how genetic information is passed on from one generation to the next.	Explore patterns in the inheritance of genetically controlled characteristics.
	(b) Investigate examples of contemporary application of genetics.	Explain the importance of variation within a changing environment.
7	*Under achievement objectives:*	*Under Evolution:*
	Describe and explain the reasons for the special characteristics of New Zealand's plant and animals.	Understand that DNA and the environment interact in gene expression.
	Describe processes that may lead to genetic variation, and understand the implications of these for plant and animal breeding.	

Table 1 (continued)

Level	Reference to evolution in the 1993 curriculum document (MoE 1993).	Reference to evolution in the 2007 curriculum document (MoE 2007).
8	*Under achievement objectives:*	*Under life processes, ecology, and evolution:*
	Investigate and describe the diversity of scientific thought on the origins of humans.	Understand the relationship between organisms and their environment.
	Under sample learning contexts:	Explore the evolutionary processes that have resulted in the diversity of life on Earth and appreciate the place and impact of humans within these processes.
	Evolution, Origin of species	

level 1 by explaining that some species have become extinct, that "living things we have in the world have changed over long periods of time" and "that some living things in New Zealand are quite different from living things in other areas of the world". While both documents include specific conceptual building blocks of evolution, the 1993 curriculum allows much more wriggle room for those who have philosophical issues with the concept. However, the 2007 version leaves little room for alternative interpretations, explicitly stating that students "should learn about where and how life has evolved, and about evolution as the link between life processes and ecology" (p. 20). At levels 5 to 7 of the evolution strand learning objectives are devoted to genetics, including genetic mechanisms of inheritance and environmental influence on gene expression. At level 8 it is expected that students will learn about the "relationship between organisms and their environment and the evolutionary processes that have resulted in the diversity of life on Earth" and will come to "appreciate the place and impact of humans within these processes" (Ministry of Education 2007). The 2007 document takes a much stronger position, not only in using the term evolution, but in firmly placing it as one of the conceptual cornerstones of modern biology.

Thus, in the 2007 document evolution is explicit at all levels of the curriculum, so that the concept should be introduced to all new entrants and their understanding expanded and extended as they progress through school. However, for this to be achieved there is an obvious need for the development of new resources and teacher professional development. Teaching science and the methods it uses to understand the natural world means also to understand its limitations. Pigliucci (2002, p.144) points out that "science is not about finding the final (ultimate) answers" but that the scientific method provides ways to confirm or challenge certain findings, some of which are so robust that they become fundamental parts in the scientific understanding of the world. Hence, an understanding of the nature of science seems paramount to students' understanding and acceptance of evolution.

The Nature of Science, Values and Evolution in the New Zealand Curriculum

It has been argued that an increased understanding of the nature of science is essential to reduce conflicts around the concept of evolution and to distinguish between what is science and what is not (McComas et al. 1998). However, the nature of how scientific knowledge is shaped is not unproblematic (Chalmers 1999) and teaching the nature of how scientific understanding is constructed has been described as an equally challenging task (Hipkins et al. 2005). Teaching the nature of science was introduced in the 1993 New Zealand curriculum document as one of the integrated strands under 'Making sense of the nature of science and technology' (Ministry of Education 1993). Hipkins et al. (2005) point out that there was a clear intention here to increase students' scientific literacy. However, this integrated strand suffered from being at times interpreted as the 'technology strand' (Baker 1999 in Hipkins et al. 2005) and also from its positioning within the document, physically separated from the contextual strands (living, material, and physical world and planet earth and beyond) and often regarded as "the pages we just turn over" (Loveless and Barker 2000). In contrast, the 2007 version of the science curriculum places the nature of science at the forefront of science achievement objectives at all levels of learning, highlighting the intention that students should come to understand the nature of science, learning to investigate and communicate about science, and participate and contribute in science. While this does not address the actual difficulties faced by teachers in addressing learning about the nature of science, it does grant it the same level of importance as the subject content areas.

Like its immediate predecessor, the 2007 document contains the four disciplinary strands. The overview of the contextual living world (biology) strand states that: "Students [will] develop an understanding of the diversity of life and life processes, of where and how life has evolved, of evolution as the link between life processes and ecology, and of the impact of humans on all forms of life" (Ministry of Education 2007). This is a much stronger statement than the 1993 expectation that students will "understand how organisms grow, reproduce, and change over generations" (Ministry of Education 1993). Lying above and unifying the subject strands is the nature of science strand:

> Through it, students learn what science is and how scientists work. They develop the skills, attitudes, and values to build a foundation for understanding the world. They come to appreciate that while scientific knowledge is durable, it is also constantly re-evaluated in the light of new evidence. They learn how scientists carry out investigations, and they come to see science as a socially valuable knowledge system. They learn how science ideas are communicated and to make links between scientific knowledge and everyday decisions and actions (Ministry of Education 2007).

This is an important statement, as students are arguably more likely to accept a concept like evolution if they can see how that concept has developed, rather than being presented with it as a 'fait accompli' (Passmore and Stewart 2000, 2002). However, whether having students learn more about the nature of science has the potential to reduce tensions between personal beliefs and the teaching of evolution has yet to be seen.

The 2007 curriculum document also puts an emphasis on giving attention to values in science education; for example, the need for culturally responsive teaching of science to address the value systems of Māori and Pasifika students in particular (Glynn et al. 2008). Values are equally important for the teaching of bioethical considerations (Jones et al. 2007) and have been identified as being important considerations for teachers when teaching evolution (Dagher and Boujaoude 1997).

Keown et al. (2005) examined the position and teaching of values in the previous (1993) New Zealand curriculum. The authors looked at the role that values play in a curriculum and point out that this includes the values expressed in the general aims, purposes and principles of the document, but that they are also evident—in a more or less explicit form—in a curriculum's presentation of content. Keown et al. note how difficult it is for students to begin to apply multiple value systems, including scientific values, to universal problems and recognise that unless teachers receive specific training this is a problematic task to achieve. Similarly Reiss (2007) comments that while in his opinion the science/religion debate could be a useful vehicle in science classrooms to demonstrate what each discipline can and cannot address it depends on how well and how adequately a teacher is equipped for such a discussion.

Issues for Schools, Teachers, and Government Bodies: the Way Forward

While the 2007 New Zealand science curriculum has implemented some important steps to strengthen the presence of evolution and the nature of science, the document lacks meaningful examples that help teachers to develop their classroom teaching in these areas. One argument could be to keep the two discussions separate—on the one hand to highlight the nature of science and its relationship to societal values, and on the other hand state plainly what constitutes essential content to be learned in biology, earth science and the other science curriculum areas. However, such a position can be particularly problematic when picked up and interpreted by special character schools in their enacted curriculum.

Since 1992 New Zealand parents have full rights to choose their children's schooling, with the intention being that this market driven change would encourage competition for the betterment of education. However, research reports that this in fact seemed to have the opposite effect for the quality of student learning (Ladd and Fiske 2003). Competing for students and more importantly their parents seems to have a negative effect on teachers' relationships, thus compromising education. Given that the new changes to the curriculum will take some time before they are completely implemented (Bell and Baker 1997) there will be a need to support teachers through professional development (Bell and Gilbert 1994) in order for the curriculum changes to take effect. This is particularly important for both the 'nature of science' area in general, and evolution in particular, as many teachers may lack the resources and experience needed to give these topics the attention demanded by the new curriculum.

Since 1993, science has been compulsory for all students up until the end of year 10 (form 4), beyond which point it becomes an optional subject. Schools offer 'General Science' for the first three years (yrs 9–11) of secondary school (at some schools this may be split into physics, biology and chemistry in year 11). General science comprises several curriculum 'strands': biology (Living World), chemistry (Material World), physics (Physical World), and earth sciences and astronomy (Planet Earth and Beyond). Those students who decide to continue in the sciences in years 12–13 may study the specialist disciplines of physics, chemistry, and biology (alone or in combination) *or* general science (alone, or in combination with one of the specialist disciplines). Thus the emphasis on students learning about evolution from the new entrant stage is to be welcomed, as not all students will be studying biology beyond year 10 and so would otherwise not be exposed to this important concept.

In addition, the way student learning is assessed has an impact on how evolution (along with other topics) is taught. In 2002 New Zealand moved from a system of norm-referenced national end-of-year examinations for year 11–13 students to the use of Achievement and Unit Standards, which describe the individual's performance against a range of performance indicators. Thus, for assessment purposes, the broader curriculum is broken down into a series of standards, with a somewhat narrower focus. Given the natural tendency of students, parents and teachers to expect that students will be prepared for assessment, this can at times mean teaching to the standards rather than approaching the curriculum as an integrated entity in breadth and depth. Since evolution is addressed in several individual standards, there is concern that students may not recognise that it is an integrating principle across the biology curriculum. This is exacerbated by the fact that standards are examined in isolation: it is difficult for examiners to use material from one standard as a context for another, given that individual students may not have studied both standards.

This is because, while all the sciences offer a range of standards at each year of senior schooling, schools do not have to offer the full range and in practice many do not, due to time constraints or the demands of competing and/or complementary subjects. This provides an opportunity for schools to avoid those standards that explicitly teach evolution. In addition, the standards dealing specifically with evolution are restricted to the final two years of secondary school, effectively minimising opportunities to expose students to this topic (see also the description of the science standards by the New Zealand Qualifications Authority (NZQA) on its website at: http://www.nzqa.govt.nz/ncea/resources/science/index.html).

Both New Zealand-trained and overseas teachers often lack practice in reflective pedagogies that acknowledge that science in itself is a subculture and that for science learning to be more effective, teaching and learning science has to be a "culture making process" (Hipkins et al. 2005, p.248). In addition, teachers have to balance the expectations of students, parents, school trustees, local and science communities, government departments and others against the need to address curriculum and assessment requirements (e.g. Hipkins 2006), all of which requires skill and pedagogical content knowledge. Classroom practices will change only slowly if these demands and tensions are not addressed. Balancing these tensions can be difficult for even some of the more experienced teachers, as is shown by the case of Dr Michael Reiss, the ex-director of education for the Royal Society in the United Kingdom. His suggestion that teachers should discuss creationism in their science classrooms as a way of teaching about the nature of science was widely reported in a way that implied he was advocating the *teaching* of creationist beliefs, and the resulting widespread denunciations from the science and education communities led to his resignation from the Royal Society position.

Fensham (2001) addresses the issue of the level of science content knowledge needed by teachers and, drawing on international literature, he points towards the intertwinement of teacher's pedagogical and content knowledge or PCK. He reminds the reader of the relationship between teacher confidence and *what* teachers know about a content area, *how* they know this knowledge has been constructed and what *alternative* ways there are to explain the content to students (p. 34). He points out that by addressing how science knowledge is constructed it would be possibly easier for teachers to pick up new content as they go.

This is particularly relevant in addressing the challenges attributed to the level of content knowledge required to teach evolution. One possible solution is to offer tailored professional development to practising teachers that will ensure their knowledge of evolutionary biology is current. As Tidon and Lewontin (2004, p.124) note, "Evolutionary Biology... [is] a complex and interactive science, where a deep understanding of the subject not only demands knowledge in diverse areas of biology, but also of geology, mathematics and philosophy, among others. Such knowledge is often inaccessible to the majority of specialised professionals, including... teachers." Studying a cohort of Brazilian biology teachers, they found that 60% of the teachers reported difficulty in teaching about evolution, attributed largely to lack of teacher knowledge, of supporting materials, and of classroom time. While primary teachers are reported to lack the science content knowledge to teach this topic confidently (Appleton 2003; Bloom 1989), this may not be as pronounced for secondary school teachers in New Zealand. Some excellent textbooks are available;

however pressure on teaching time remains a significant issue. There are additional problems associated with students' alternative concepts relating to topics such as natural selection, adaptation, speciation, and fitness. Tidon and Lewontin also comment that the order in which teaching material is presented can cause difficulties for students: while evolution and natural selection are central to an understanding of modern biology, for reasons related to conceptual difficulty "... it has been suggested that the topic should be dealt with in the later grades" (Tidon and Lewontin 2004, p.128). And they specifically recommend the provision of ongoing teacher development and support, in addition to "the instruments of instruction for these teachers in terms of strategies for teaching (Tidon and Lewontin 2004)—something which was present in the 1993 New Zealand curriculum document but is lacking from the 2010 version. They also recommend use of an historically rich curriculum for teaching evolution—this would help to meet the requirements of the new New Zealand curriculum to teach the nature of science (see also Alles 2001) but also requires resourcing.

However, teachers also need sound pedagogical guidelines if they want to include controversial issues in their teaching, especially if they are of a socio-scientific nature. Levinson (2006) argues for a theoretical model consisting of three strands: first to create an environment of 'reasonable disagreement' that is built on the pluralist relationship between rationality and reasonability (p. 1207). He continues with the need to identify and understand the nature of communication or 'communicative virtues' as he describes it and then to identify the ways of why and how people arrive at their positions in order to 'illuminate those disagreements' (p.1207). For science teachers this implies the need to break away from the authoritative position science often assumes and embrace pedagogical practices that are responsive to cultural dispositions, thus strengthening the discussion about what science can and cannot answer. This approach would also require teachers to appreciate not only the nature of science but understand also the nature of religion and where evidence for argumentation is taken from—either from the natural world or from theological scriptures (Reiss 2008).

Nelson (2008) identifies three teaching strategies that teachers can use to enhance student learning about evolution: interactive engagement, teaching about critical thinking (which would again support learning in the nature of science strand), and using both to help students compare their conceptions and misconceptions to scientific understandings. This approach mirrors that taken by Passmore and Stewart (2000, 2002), who found that inquiry-based lab classes encouraging students to actively interrogate different models of evolution (creationism, Larmarckism, Darwinian evolution) enhanced their understanding of this key concept. Along with examples of teaching approaches, Nelson provides a list of resources that teachers can use to enhance both their teaching and their own understanding; however, this focuses on the US system and we recommend the development of similar catalogues of resources for New Zealand teachers. Similarly, the provision of materials that directly address common student misconceptions would be valuable: Nelson comments that "[students'] pre-instructional conceptions are typically little altered by traditional science teaching" (2008, p.218), and that interactive engagement is essential in overcoming them (see also Scharmann 2005). In addition, Nelson suggests teaching about 'intelligent design' creationism during classes on evolution—not because it is a valid alternative to the theory of evolution, but because showing how IDT is *not* science can lead to a deeper understanding of the nature of science itself. Again, this would meet the requirement for students to learn about the nature of science, but this requires recognition that this would result in a reduction in the amount of content that can be delivered—something that should be debated and discussed at a national level.

To address the complexity of implementing a new science curriculum and to take on the challenge of implementing the concept of evolution, teachers in New Zealand will need support mechanisms that address not only teaching and learning approaches and pedagogies that are reflective of the cultures that students bring with them when they enter the science classroom and nature of science, but also support and understanding from within the educational community. The launch of a website specifically catering for New Zealand teachers in 2004 was a first step in this direction. The 'Evolution for Teaching' website (http://sci.waikato.ac.nz/evolution) provides resources for teachers to read or use directly with their students in class (Otrel-Cass et al. 2005), but still more support will be needed with the implementation of the new curriculum.

Conclusions

Teaching about evolution offers valuable opportunities to discuss the nature of science and show how science derives its understanding of the natural world by empirically resolving theoretical disagreements. Yet despite the fact that the theory of evolution is a cornerstone of modern biology, its inclusion in various iterations of the New Zealand curriculum documents has regularly sparked protests from various lobby groups due to their perceptions that evolution threatens systems of values and personal beliefs. In emphasising the significance of biological evolution, the 2007 New Zealand curriculum has sent a strong signal to science teachers and educators about the need to take action in developing their students' understanding of the importance and implications of biological evolution. However, given the degree of controversy over teaching evolution, in New Zealand and elsewhere, it is essential to provide teachers with the support, resources, and professional development needed for them to help their students understand not merely the fact and theory of evolution, but also how science has arrived at its current state of knowledge in this key area of biology. Success in this area will also enhance students' understanding of the nature of science itself, thus meeting one of the key precepts of the new Science curriculum.

Acknowledgements Our thanks to the late Peter Spratt for information provided through informal chats and e-mail discussions.

References

Alles, D. L. (2001). Using evolution as the framework for teaching biology. *The American Biology Teacher, 63*(1), 20–23.

Appleton, K. (2003). How do beginning primary school teachers cope with science? Toward an understanding of science teaching practice. *Research in Science Education, 33*(1), 1–25.

Bell, B., & Baker, R. (1997). *Developing the science curriculum in Aotearoa New Zealand*. Auckland: Addison Wesley Longman.

Bell, B., & Gilbert, J. (1994). Teacher development as professional, personal, and social development. *Teaching and Teacher Education, 10*(5), 483–497.

Bloom, J. W. (1989). Preservice elementary teachers' conceptions of science: science, theories and evolution. *International Journal of Science Education, 11*(4), 401–415.

Chalmers, A. (1999). *What is this thing called science?* Hackett Publishing Company: Indianapolis, IN.

Dagher, Z. R., & Boujaoude, S. (1997). Scientific views and religious beliefs of college students: the case of biological evolution. *Journal of Research in Science Teaching, 34*, 429–445.

Education Gazette. (22 August 2003). Ministry of Education, Wellington, NZ.

Fensham, P. (2001). Science content as problematic—issues for research. In H. Behrendt et al. (Eds.), *Research in science education—past, present, and future* (pp. 27–42). New York: Kluwer Academic.
Glynn, T., Cowie, B., & Otrel-Cass, K. (2008). *Quality teaching research and development science hub (Waikato): Connecting New Zealand teachers of science with their Maori students*. Hamilton: Wilf Malcom Institute for Education Research, The University of Waikato.
Hipkins, R. (2006). Ontological possibilities for rethinking teaching of the 'nature of science'. PhD thesis, Deakin University, Australia. Retrieved from the Australian Digital Theses Program http://tux.lib.deakin.edu.au/adt-VDU/public/adt-VDU20070801.154606 (access date 22 September 2008).
Hipkins, R., Barker, M., & Bolstad, R. (2005). Teaching the 'nature of science': modest adaptations or radical reconceptions? *International Journal of Science Education, 27*(2), 243–254.
Jones, A., McKim, A., Reiss, M., Ryan, B., Buntting, C., De Luca, R., et al. (2007). Research and development of classroom-based resources for bioethics education in New Zealand: Final Report. Commissioned research report.
Keown, P., Parker, L., & Tiakiwai, S. (2005). *Values in the New Zealand curriculum*. Wellington: Ministry of Education.
Ladd, H. F., & Fiske, E. B. (2003). Does competition improve teaching and learning? Evidence from New Zealand. *Educational Evaluation and Policy Analysis, 25*(1), 97–112.
Levinson, R. (2006). Towards a theoretical framework for teaching controversial socio-scientific issues. *International Journal of Science Education, 28*(10), 1201–1224.
Loveless, M., & Barker, M. (2000). "Those pages we just turn over ...": the 'nature of science' in science in the New Zealand curriculum. *New Zealand Science Teacher, 93*, 28–31.
McComas, W. F., Clough, M. P., & Almazroa, H. (1998). The role and character of the nature of science in science education. *Science and Education, 7*(6), 511–532.
McGeorge, C. (1992). Evolution in the primary school curriculum. *History of Education, 21*(2), 205–218.
Ministry of Education. (1993). *Science in the New Zealand curriculum*. Wellington: Learning Media Ltd.
Ministry of Education. (2007). *The New Zealand Curriculum for English-medium teaching and learning in years 1–13*. Wellington: Learning Media Ltd.
Nelson, C. E. (2008). Teaching evolution (and all of biology) more effectively: strategies for engagement, critical reasoning, and confronting misconceptions. *Integrated and Comparative Biology, 48*(2), 213–225. doi:10.1093/icb/icn027.
Nichols, L. (2008). Christians challenge teaching of evolution. The Dominion Post, Saturday June 28. Available on-line: http://www.stuff.co.nz/dominionpost/4599813a6000.html (access date 2 October 2008).
Numbers, R. L., & Stenhouse, J. (2000). Antievolutionism in the Antipodes: from protesting evolution to promoting creationism in New Zealand. *The British Journal for the History of Science, 33*, 335–350.
Otrel-Cass, K., Earl, K., Campbell, A., & Cooke, P. (2005). Evolution for teaching: website evaluation report. *The New Zealand Science Teacher, 109*, 27–29.
Passmore, C., & Stewart, J. (2000). A course in evolutionary biology: engaging students in the "practice" of evolution. National Centre for Improving Student Learning & Achievement in Mathematics & Science. Research report #00-1, pp. 1–11.
Passmore, C., & Stewart, J. (2002). A modelling approach to teaching evolutionary biology in high schools. *Journal of Research in Science Teaching, 39*(3), 185–204.
Peddie, W. S. (1995). Alienated by Evolution: the educational implications of creationist and social Darwinist reactions in New Zealand to the Darwinian theory of evolution. Unpublished PhD thesis, University of Auckland.
Pigliucci, M. (2002). *Denying evolution: Creationism, scientism, and the nature of science*. Sunderland: Sinauer.
Reiss, M. J. (2007). Imagining the world: the significance of religious worldviews for science education. *Science and Education*. doi:10.1007/s11191-007-9091-9.
Reiss, M. J. (2008). Should science educators deal with the science/religion issue? *Studies in Science Education, 44*(2), 157–186.
Scharmann, L. C. (2005). A proactive strategy for teaching evolution. *The American Biology Teacher, 67*(1), 12–16.
Scott, E. C., & Branch, G. (2003). Evolution: what's wrong with teaching the controversy? *Trends in Ecology and Evolution, 18*(10), 499–502.
Tidon, R., & Lewontin, R. C. (2004). Teaching evolutionary biology. *Genetics and Molecular Biology, 27*(1), 124–131.