Faction or fiction: Using narrative pedagogy in school science education

Jane Gilbert, Rosemary Hipkins, and Garrick Cooper

New Zealand Council for Educational Research

Paper presented at the **Redesigning Pedagogy: Research, Policy, Practice** conference, Nanyang University Institute of Education, Singapore, 30 May –1 June 2005

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Abstract

Feminist and post-colonial research have highlighted learning issues for students who do not see a place for themselves within science, as this is traditionally represented in school science education. The use of narrative pedagogy is seen by some as a means of overcoming some of these issues, but translating the intention to use narrative into actual classroom resources is less well understood. This paper outlines some issues that arose during the writing of two sets of narrative materials to support science learning in New Zealand's *kura kaupapa Mäori* schools. We found that narrative can easily become "faction" rather than "fiction" when the story's primary purpose is to teach science. Such stories still belong predominantly to the teller and do not necessarily resolve the identity issues that narrative pedagogy seeks to address. Building on our experiences to date, we suggest some instances in which paper-based narratives can be successful, but we also identify clear limitations to such resources. We then explore the proposal that digital story telling may be an effective means of addressing the unresolved issues.

Since its beginnings, school science education has had two conflicting aims. On the one hand it is supposed to develop the scientists of the future, while on the other it is supposed to provide everyone with a basic understanding of science. Research over the last 20 years or so tells us that science education programmes in most countries are not very successful in achieving either of these aims, and the numbers of students studying science at tertiary level continue to decline. Science as it is taught in schools is clearly not very attractive to a great many people, and as a result most people don't have a very good understanding of science. For a variety of reasons this is widely seen as a problem, with the result that science education research is now a large—and growing—field.

Recently, some science educators have advocated using stories to teach school science (see, for example, Barker, 1997, 2004; Gilbert, 2001; Millar & Osborne, 1998; Solomon, 2002; Sutton, 1992). Some argue that stories can illustrate or provide "background" for the science concepts being taught. Others see them as a way to start the kinds of ethical discussions that are now required in many school science courses. Another group sees stories as a way of adding "human interest" to science and/or making it more "relevant" and/or interesting. A fourth group argues that stories are a way of "including" students who find science inaccessible and alien. We are in this last group. We are interested in finding out whether or not stories *can* be used to make science more "inclusive". If this is a good idea in theory, how might it actually be done in practice? What issues does this raise? What are the pitfalls? Does it work? *Does* this approach draw students into science? Do the students actually *learn* science? Does it make them want to learn *more* science?

In this paper we explore some of these issues via a discussion of one attempt to use stories to teach science. First we look at why, in theory, using stories to teach science seems to be a good idea. We look briefly at the features of "good" stories, and explore how they might be used in science contexts. Then we discuss the development and implementation of some science stories that were designed for use in *kura kaupapa Mäori*[1] in New Zealand. In the last section of the paper we explore some of the issues that arose and suggest some next steps.

What are the arguments for using stories to teach science?

For most people science is a difficult subject. Learning science—as it is traditionally taught—involves learning to think "scientifically". While thinking scientifically is often *cognitively* challenging, there is another more basic reason for science's difficulty. Thinking scientifically doesn't "come naturally" to most people. It is different in *kind* from ordinary, "everyday" forms of thinking. Because it is abstract, a-contextual and often counter-intuitive, it is unfamiliar and, from the standpoint of everyday experiences and concerns, often quite alien.

The educational psychologist Jerome Bruner explores this idea in his 1986 book *Actual minds, possible worlds*. He argues that there are two quite distinct modes of cognitive functioning. These two modes of thinking complement each other: however, they are very different in terms of the way they order experience and construct reality. For Bruner, one mode cannot be seen in terms of—or reduced to—the other. *Both* are necessary for understanding what he calls our "rich diversity of thought". Bruner calls one of these modes of thought the "paradigmatic" or "logico-scientific" mode, and the other the "narrative" mode.

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[1] *Kura kaupapa Mäori* are schools in which children are taught entirely in *te reo Mäori* (the language of the Mäori—or indigenous—people of New Zealand), and according to Mäori *kaupapa* (Mäori principles or ways of doing things). See below for more details.

The aim of the "paradigmatic" mode is to make sense of the world. It does this by abstracting itself from everyday life, by distancing itself from the feelings and concerns of people. Its aim is to develop formal, logical proofs or theories that explain how the natural world works. The "narrative" mode, on the other hand, also aims to make sense of the world. However, it does this in a very different way. People, rather than being excluded, are foregrounded. Their actions, motivations, and relationships are structured and explained through stories. According to Bruner, all normally developing human beings learn to think in the narrative—or story—mode, but comparatively few become really competent in thinking logico-scientifically.

Thus, stories are important to everyone (in all cultures) and everyone understands how to think in stories. All cultures and nations have "origin" stories: stories about where their members came from, how they are related, and how they continue to be connected to each other. Local communities and individual families usually also have similar kinds of stories about themselves. Psychologists agree that it is extremely important in young children's development that they are told stories, that they are able to tell stories about themselves, and that those stories are listened to and valued by people who are close to and important to them (Campbell, 1997; Egan, 1986). Stories are an important means through which people engage with each other, first with those who are close to them, and later, with the other members of the culture/nation they have been born into, and with that culture's/nation's knowledge systems. They are also extremely important in the formation of an individual's sense of identity: they create the context within which an individual develops a sense of self, a sense of their place in the world, and a sense of what their place in the world *could* be (Connelly & Clandinin, 2000; MacIntyre, 1981; Miller, 1995; Polkinghorne, 1988; Sarbin, 1986;). Stories also develop an individual's capacity for imagination and creativity, the ability to imagine worlds that are very different from the one they are in right now, and the ability to imagine themselves doing and being things that are very different from their current reality. Thus stories do not simply reflect a person's "reality": they play an active role in constructing it (and they can play a role in transforming it).

It is for all these reasons that stories play an important role in early years education. However, there are some very good arguments for using stories more widely—beyond the early years and in contexts (like science) where stories are not normally considered appropriate. The first argument is basically a cognitive one. If everyone understands how to think in stories, then why not use stories as a way *into* other modes of thought? If, as Bruner argues, the narrative and logico-scientific modes are distinct and irreducible, and if one develops before the other, then why not use one as a kind of bridge to the other? Learning *about* science doesn't have to involve thinking "scientifically", at least not in the early stages. The current received wisdom is that it does: however, we don't explicitly scaffold the transition from narrative to scientific thinking. Most students never understand the distinction, and as a result they find science "difficult". However, if we could teach science, at least initially, using a mode of thought they already understand (even if the science they learn isn't "real" science), then perhaps more students might be engaged for longer. Later, once a foundation of basic knowledge has been established, the transition from narrative to scientific thinking can be explicitly and carefully managed. The question then becomes one of how and when to do this (and this is an issue we return to later in the paper). Taking such an approach clearly distinguishes science *education* from science itself. For scientists, scientific knowledge is objective, value-free knowledge. It is knowledge that has been derived from processes designed to ensure that it isn't contaminated by the everyday feelings and concerns of those who developed it: that is, it is derived from *non*-narrative forms of thinking. This view of scientific knowledge is of course contested by many philosophers and sociologists of knowledge: however, it is the basis of most science education programmes. For most people, science is an alien—and therefore difficult—way of understanding the

world. If it is important for people to know about science, then careful scaffolding is needed, scaffolding that, at least in the early stages, makes it possible for people to construct and re-construct their sense of themselves in relation to this knowledge. Stories are an obvious way to do this.

This brings us to the second—affective—argument. This argument has to do with the way stories are used in identity building. If stories are used by people to develop their sense of self, and a sense of their place in the world, and if science is presented as a form of knowledge that is, by definition, *not* stories, then most people will find it hard to imagine themselves participating in science. If they are to learn to think "scientifically", most people need some sort of motivation. They also need a context. They need some way of imagining themselves as "having a place" in science. Most people will need some sense of science as a human activity, done by real people with real motivations, interests, and feelings, and most people will need to be able to see people *like them* doing these things. School science, presented as it is, as "the facts", finished non-negotiable knowledge, does not make this easy. The result of this is that, for most people, science is *either* something you study because you need it for something else you want to do in the future (in which case you do it in a passive, rule-following way, as a spectator who isn't really involved), *or* something to be avoided as soon as it is possible to do so.

These two arguments focus on "business-as-usual": that is, *today*'s ideas about what students should learn in science, and why they should learn it. The third argument for using the story mode more widely is oriented more towards the future. The Knowledge Age literature tells us that the meaning of knowledge is changing. Knowledge is no longer "stuff" you acquire and store away for future use. Instead it is increasingly being thought of as if it were a form of energy, something you *do* things with, something you use to make *new* knowledge (Castells, 2000; Gee, Hull, & Lankshear, 1996; Lash & Urry, 1994; Mulgan, 1998; Neef, 1998; Stehr, 1994). In this new age, people need new skills. They still need traditional forms of knowledge (like science), but they now need them for quite different reasons. They need the "old" disciplines, not so they can reproduce them and follow their rules, but so that they can use them to develop completely new knowledge. They need the ability to put elements taken from one knowledge system into other, completely different knowledge systems, re-arranging them to make them "work" in new ways. (Lyotard (1984) calls this "performativity".) This new "knowledge work" requires people to be able to move easily between different knowledge systems, translating and mediating between them as they go. They need to be able to think, not in terms of detailed facts, but in "big picture" or "systems" terms. The result of all this, if we accept it, is that people need an orientation to knowledge that is very different from the one they are given in today's schools. They need to see knowledge, not as divided into separate fields, but as a series of connected *systems*. They need to know, not the detailed "facts" of a discipline, but how that discipline "works" as a system, and how it is different from other systems. They need to know what kinds of problems each system is good at solving, and what kinds of problems might be best solved using another system. Preparing people for this kind of "knowledge work" requires us to rethink how we teach the traditional disciplines (Gilbert, 2005). One way of doing this is to think of each discipline in terms of the stories it tells about itself–how it came to be, how it works, why it is important, who its main characters are, and so on. Such an approach is, we think, capable of developing the kind of "systems-level" understanding of knowledge that seems to be a defining feature of the Knowledge Age.

Thus, using stories for teaching science beyond the very early years of education is—at least in theory—a good way of helping more people (and a wider range of people) to successfully learn about science. In addition, this approach is also useful as a way of giving people the orientation to knowledge they need for successful participation in the knowledge-based

societies of the future. So much for the theory. What happens when we try to put these ideas into practice? What exactly *is* a story? How do we decide whether a story is a *good* story? What is a good story in science contexts? If we do manage to develop some good stories with science themes, will people learn science from them? If science *isn't* stories, then isn't it misleading to represent it as if it were?

What is a "good" story?

As we said earlier, everyone can think in stories. Most people know a good story when they hear—or see—it. However, most people wouldn't be able to tell you what *makes* a story good (just as most of us, while we can speak and effectively use language, wouldn't be able to explain the grammatical rules we are using when we do this). For most of us, the ability to understand, use, and appreciate stories is tacit, cultural knowledge. It relies on a deep knowledge of people—their feelings and concerns, their relationships to others, and what they are likely to do in particular contexts.

Narrative theory is an attempt to formally articulate this implicit "cultural" knowledge. It tells us that "successful" stories have certain key features. All stories have characters or roles, some sort of time sequence, and some sort of problem or issue to be resolved. They also have a listener or intended audience who is expected to respond in particular ways, and (whether or not this is explicitly acknowledged) a storyteller–someone who organises the story's elements in particular ways in a particular order, for a particular purpose or with a particular effect in mind (Barwell, 2000). There are different "styles" or "genres" of story (for example, there are comedies, tragedies, moral fables, or myths and epics). Each genre has a different set of conventions for organising the structure of events–who acts in relation to whom, and for what purpose. People's implicit knowledge of stories includes an understanding of genre (although again, unless they have explicitly studied these things, they are unlikely to be able to explain how they know what they know). If the genre shifts as the story is told, it will seem wrong, and people will feel tricked (unless, as sometimes happens, there is a clear purpose for doing this).

Can all this be applied in science contexts? Are some genres better for science contexts? If so, why is this? Can science stories be good stories? Or are stories inevitably not "proper science"? This paper explores some of these questions via a discussion of one attempt to use stories to teach science in a particular context. The stories we discuss were developed for use by teachers in *kura kaupapa Mäori.* They are told in the Mäori language and are designed to fit with the objectives of the *kura kaupapa Mäori* movement in New Zealand. However, before describing the stories, it is probably helpful to first provide some background on the *kura kaupapa Mäori* movement in New Zealand.

Background to *kura kaupapa Mäori* education

Kura kaupapa Mäori—literally "Mäori worldview schools"—were first established in New Zealand in the early 1980s. They were set up, financed, and resourced by Mäori parents and communities, independently of the state, in response to what was widely seen as a linguistic and educational crisis (Smith, 2003). The proportion of Mäori children able to speak Mäori

had fallen to such low levels that the language was in imminent danger of extinction,[2] and Mäori children were over-represented in negative schooling statistics (suspensions, expulsions, and leaving school with no qualifications). Mäori parents and communities responded to this by looking for their own answers, rather than waiting for the state, and *köhanga reo*[3] and *kura kaupapa Mäori* were the result. About 10 years after the first *kura* were set up, the New Zealand Government began to fund them. This was seen as being part of its obligations under the Treaty of Waitangi.[4] However, government funding brought with it a series of obligations and responsibilities, some of which are contentious for the members of the *kura kaupapa Mäori* movement. By 2003 there were 61 state-funded *kura kaupapa Mäori*, and 33 Mäori immersion schools (very similar to *kura kaupapa Mäori*). About 8 percent of Mäori children were attending these schools, and 14 percent overall were attending schools with more than 30 percent of the curriculum being taught in the Mäori language (Ministry of Education, 2004).

These schools have played an important role in the revitalisation of the Mäori language that is taking place in New Zealand. However, they face a number of challenges, many of which have to do with the fact that they are still a relatively new initiative. For example, it has been difficult to train enough suitably skilled *kaiako* (teachers) who are fluent in the Mäori language *and* who also have enough curriculum knowledge. The Government recently put a moratorium on new *kura kaupapa Mäori*, mainly because of the difficulties in recruiting suitably qualified staff.

Secondly, there are not enough quality Mäori language teaching resources. As a result, a great deal of teacher energy is taken up in translating English language resources for use in *kura* and/or creating new resources. This difficulty has, to some extent, come about as a result of the partial assimilation into the "mainstream" of *kura*–as they became government-funded. *Kura* are now required to teach all the subjects of the "mainstream" curriculum. Because the knowledge underpinning some of these subjects (science and mathematics are the standout examples) is not *Mäori* knowledge, there are often no suitable Mäori words to express it. Thus a great deal of energy has been put into coining new Mäori words (often from archaic sources) to allow these subjects to be taught in Mäori. This is a major burden, first for the translators, and then for the teachers (who are unlikely to know these very low frequency or "made-up" words), and the students (who have to learn a very large number of new terms). To compound the problem, different *kupu hou* (new words) are being used in different *kura* around the country—with obvious implications for resource production and assessment of student learning.[5]

The third (related) challenge for *kura* is the issue of whose knowledge is being valued and validated. *Kura kaupapa Mäori* are not just Mäori language schools: they are Mäori *worldview* schools. Their aim is to keep Mäori knowledge—as well as the Mäori language—alive. For many in the *kura kaupapa Mäori* movement, it is not appropriate to teach the "mainstream" curriculum translated into Mäori. *Kura kaupapa Mäori* should be teaching

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2 In 1913, 90 percent of Mäori school children could speak Mäori. By 1953 the proportion had dropped to 26 percent, and by 1975 the figure had fallen to less than 5 percent (figures reported in pt. 3.3.2, Wai 11 Te Reo Mäori Claim (Waitangi Tribunal, 1986).

3 *Köhanga reo*, literally "language nests", are Mäori language preschools.

4 The Treaty of Waitangi is New Zealand's founding document, signed in 1840. It sets out a partnership between the indigenous Mäori people and the Päkehä settlers (people of mostly European descent).

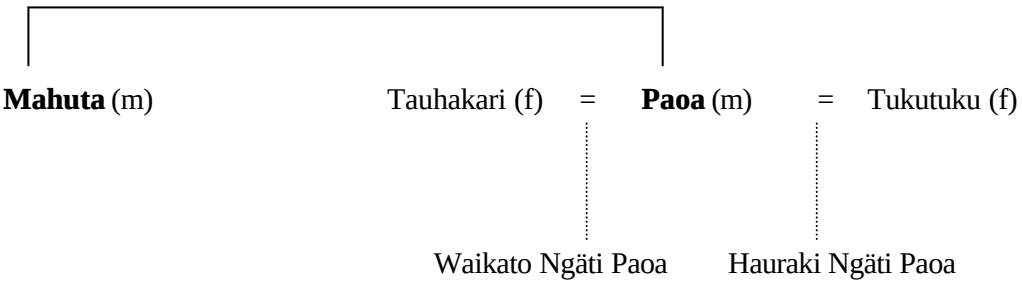
5 In a recent NZCER project, we came across at least four different Mäori terms for the English word "multiply" being used in two *kura*.

mätauranga Mäori (Mäori knowledge) in ways that are consistent with Mäori *tikanga* (Mäori principles or the right ways of doing things in Mäori contexts).

The *Tötika* resources we describe in the next section of this paper were designed to address some of these issues. Firstly—and most obviously—they are written in the Mäori language, specifically for *kura kaupapa Mäori* children. Secondly, they are a useful "bridge" for teachers as well as students—in that they provide science curriculum knowledge in an easily accessible form. Thirdly, some (not all) of the resources use traditional Mäori stories to teach traditional Mäori knowledge. They don't all do this however—some are quite explicitly designed to teach "mainstream" science knowledge.

The *Tötika* resources are stories—a strategy that has been used quite explicitly as a way to meet these objectives. Stories are widely accepted as appropriate in Mäori contexts. Why is this? Mäori culture, in pre-colonial times was an oral culture. Mäori knowledge, like that of many other indigenous peoples, is passed down via oral traditions, usually in the form of stories—such as *püräkau*, *pakiwaitara*, and *körero tuku iho* (Biggs, 1964). These stories contain important origin traditions and historical knowledge.[6] They also contain messages about accepted social behaviour, morals, and values, and/or explanations of important natural phenomena. Two of these stories are given below—to show how they work to transmit these different kinds of knowledge. The first—the story of Paoa and Mahuta—contains important historical knowledge while also demonstrating the importance of certain *tikanga* (customs). The second—the story of Tama-nui-i-te-rä (a personification of the sun) and his two wives—is given as an example of a story designed to explain an important natural phenomenon.

Paoa and Mahuta are two brothers of the Waikato tribes. Mahuta's descendants became Ngäti Mahuta—the tribe of today's Mäori monarchy. Paoa's descendants were separated into two tribes of the same name, Ngäti Paoa.[7] One day, Mahuta visited Paoa at his village.[8] As is the custom, Mahuta and his party were to be fed. Tauhakari, Paoa's wife, pleaded to Paoa that after so many visiting parties, they barely had enough food left for their children. Paoa was ashamed (*whakamä*) of his inability to provide (*manaaki*) for his guests. Such was his shame that Paoa left his wife and two sons and the Waikato region permanently. Paoa moved to Hauraki and remarried. The descendants of his second union also became known as Ngäti Paoa (Turoa, 2000).



6 See Vansina (1985) for a discussion of the historical knowledge contained in oral traditions.

7 This is still a matter of debate amongst the two confederations of tribes, Waikato and Marutuahu (Hauraki), the tribes that Ngäti Paoa are part of.

8 The name of the village was Kaitotehe and was situated on the edge of the Waikato River on the opposite side from Taupiri mountain. Taupiri mountain is also an old village site. Nowadays, it has been set aside as a burial ground for the *kähui ariki* (the Mäori royal family).

This tradition tells the story of an historical event, explaining the existence of *two* Ngäti Paoa tribes. However it also illustrates the importance of *manaakitanga* (providing hospitality) to Mäori society, and the powerful influence that *whakamä* (shame) exerted in Mäori society.

The second tradition[9] is that of Tama-nui-i-te-rä (the sun) and his two wives, Hine-raumati and Hine-takurua. The two wives have different homes and at different times of the year Tama-nui-i-te-rä goes to stay with one, and then slowly returns to the other. Hine-takurua lives at sea and Hine-raumati lives on the land. This tradition reveals knowledge about the different parts of the horizon that the sun rises from at different times of the year. Hine-raumati translates as the "summer-maid" and Takurua is the Mäori name for Sirius (the star) and for winter. This tradition is from Ngäti Awa in the Bay of Plenty region. Therefore, from their viewpoint in New Zealand, in summer Tama-nui-i-te-rä rises from over the land (in New Zealand from further south) and during winter from over the sea (from further north).

These two traditions contain—and are designed to teach— important historical information, important information about *tikanga*, and important information about certain important natural phenomena. They are but two of the very large number of different stories used by Mäori to transmit Mäori knowledge. For many in the *kura kaupapa Mäori* movement, stories such as these should form the basis of a specifically Mäori pedagogy, developed for teaching *mätauranga Mäori* (Mäori knowledge).

So, turning now to the *Tötika* stories that are the subject of this paper, do these stories "work" in ways that fit with Mäori pedagogy? Are they "good" stories? Do they work (as they were intended to) as good *science* stories? Or is doing all of these things at once just too much to ask?

The Tötika stories

Tötika, translated into English, means "right", "correct", "straight", "the proper way to do things". The Tötika stories we look at below were designed for use in *kura kaupapa Mäori*– as the "right" or "proper" way to do things in this context. They are teaching resources made up of collections of stories accompanied by teachers' guides, posters, and games. New Zealand's Ministry of Education funded their development.

The first series, *He Päkau: Ngä Manu o Aotearoa* (The Birds of Aotearoa), has four journal collections of stories that explore the science concepts of adaptation, habitat, reproduction, and migration via stories about some of New Zealand's indigenous birds. The second series, *Ngä Toka o Aotearoa* (The Rocks of Aotearoa), has three story journals that explore the geological concepts of the rock cycle and rock types, events associated with landscape formation, and human uses of rocks, especially those that were important in traditional Mäori life. At the time of writing this paper a third series, *Ngä Whetu* (The Stars) is in development. As outlined above, the stories are Mäori language resources for teachers in *kura kaupapa Mäori.* They were designed to support these teachers to include science as part of their programmes, while at the same time also supporting the teaching of *mätauranga Mäori*. Doing all of these things is of course difficult. However, it raises some interesting issues, some of which are explored below.

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[9] This tradition was recorded by Hamiora Pio of Ngäti Awa in the Bay of Plenty region in New Zealand. Professor Bruce Biggs, in his article, *Knowledge as allegory* (1994), recited and analysed the tradition that is presented here.

Maunga tiketike, Manu tiketike – kea

One of the *He Päkau* series, this is an anthropomorphic account of the "thoughts" of a young male kea, a species of mountain parrot indigenous to New Zealand. Based on ecological studies of the interaction between humans and these intelligent, inquisitive birds, the story is a moral fable intended to foster discussion of the consequences of unthinking interactions between humans and other animal species. (Kea raid mountain rubbish bins to gain access to high energy food scraps, and they are adept at ripping open aluminium soft drink cans. These activities obviate the need to spend large amounts of the day searching for food and leave kea with time to investigate/destroy the rubber parts of parked cars at mountain ski fields.) The following (translated from Mäori) illustrates the "tone" of this story:

> Sometimes visitors to the park feed us the scraps of their lunches. I'm not shy or scared of people– in fact I'll do tricks to get their attention. Sliding down snow banks is good for a laugh! I'll steal food out of packs that are left lying about if I think I can get away with it. Then there's always the rubbish bins in the park–they're worth checking out each evening when the people all leave. I know what Coke labels look like–I get a real high from that fizzy drink left in the bottom of the can.

The story obviously has a teller–the young kea. However, the reader's belief in his "voice" is completely stretched towards the end of the story when he accounts for the measures put in place to protect kea in general, and begins to "talk" well beyond his direct experience. Kea are characters likely to appeal to young readers (and to be widely familiar as they feature in television advertising for car insurance) but the "problem" that drives the narrative is a human problem, not a kea problem. While the excerpt quoted is (as far as we might imagine) written from a kea perspective, that has to change later on in the story if the didactic purpose–to teach certain important ecological concepts–is to be achieved. Thus the genre of the story changes in midstream in a way that signals this isn't a "good story", and young listeners are left with no role beyond accepting the "facts" they are being told. By comparison, the story of Paoa and Mahuta (see above) also has a didactic purpose, but uses real people with real issues to develop this theme. Listeners can be expected to empathise with Paoa and Mahuta and their problems, and to intuit what they might have to do to avoid having this problem themselves. While some listeners may have been in a position to decide not to leave high-energy rubbish in mountain car parks, many children will not be able to directly relate to this story at all.

Hoki atu Paihamu mä

Translated as "possums go home", this is a rhetorical story structured along the lines of Aladdin's lamp. Children are invited to consider what animal pest they might banish from Aotearoa, given the magical chance. The story begins with the narrator, who speaks directly to the reader, deciding to expel cats, which in the tradition of such stories has unforeseen consequences–here a population explosion of mice. After several such attempts the narrator finally concludes we could probably expel the (non-indigenous) Australian Possum (*paihamu*) without creating another unforeseen ecological disaster. The opening sentences of the story (translated from Mäori) illustrate its "tone":

> If you were given magic powers to boot one type of animal pest out of Aotearoa, what would you choose? I think I might choose cats. I hate it when they catch and kill our birds–especially my favourite little garden birds. I'd use my magic powers and say 'Cats! Go home and don't come back!' (I wonder where exactly is 'home' for cats? I know lots of European settlers brought them here with them, but where did cats come from first of all?)

Like the kea story, this one has characters, a problem, and a teller. But this problem, while very real to ecologists, is rather contrived from the child's point of view. They were not responsible for the introduction of these mammals into New Zealand and, as the last sentence in the above quote shows, it may be impossible to determine where exactly one might send an introduced pest "home" to—even supposing the impossible could be done. The real Aladdin's lamp story speaks to themes such as greed and children can intuit the moral. The only real similarity here is that consequences of actions may not be foreseen. Again the story belongs to the teller, not the listeners, and its purpose is clearly didactic.

Te Horonga o Maunga Aoraki

This is an "eye witness" first person account of the night a large section of land slipped away from the summit of Aoraki–Aotearoa/New Zealand's highest mountain and part of the Southern Alps. The event was witnessed at relatively close quarters by a group of climbers in a mountain shelter, the friction creating flashes of light in the darkness. The consequences were clear for all to see the next day. The following (translated from Mäori) illustrates the story's style:

> By the time we'd wriggled out of our sleeping bags and grabbed our jackets and boots, the rumble had become a roar. What was going on? We looked out the door carefully. From the direction of the top of the mountain orange sparks flashed. Then swhoosh! A huge blast of moving air hit us in the face. The top was falling off the mountain! That 'wind' was caused by the rock-slide racing down the mountain side. The sparks were made by the rocks that had broken free. They hit other rocks as they tumbled along in almost free-fall, striking sparks from the violent contact. It took two whole hours for that huge landslide to stop. Two hours! That's an awful lot of mountain to be on the move.

While dramatically told, the story strikes a false note with its timing of the explanation. In the first place, who would think first of geology when faced with what must have been a life-threatening situation? (If the climber talking here had a problem, it was likely to have been the need to find a way of staying alive in the face of such an event.) In the second place, the cause and scale of the damage was not apparent until daylight broke. Perhaps, given the scale and frequency of various geological events that all people in Aotearoa/New Zealand must learn to live with, this story could have been told in a way that spoke to children's very real fears. But then, would the geological details have been "lost" in the drama? Again, the didactic purpose is at odds with the narrative demands. (Or, alternatively, it could be argued that the demands of the narrative are beyond the creative power of—and time available to—a writer with the necessary science and educational knowledge—in this case, one of us.)

Te Hekenga Kuaka

Some of the Tötika stories are set in classrooms. The "plot" of these rather contrived stories centres on a learning experience and is usually narrated from the first person perspective of a student the same age as the learners. For example, *Te Hekenga Kuaka* tells the story of the discoveries made by a boy called Wiremu and a girl called Reihana as they investigate migration of the Kuaka (Godwit) between Aotearoa and the Arctic Circle. The didactic purpose is all too evident:

> Reihana wants to think of a good question too. She writes on her paper and puts it in the question box…. Why are kuaka so mean? The teacher reads Reihana's question. 'You need to do some work on this question before you can investigate it Reihana,' he says. They have a chat. Soon her question looks like this: How can young kuaka get to Alaska without any parents to show them the way?

Here the children are being trained to be young scientists, framing questions in ways that can be empirically answered. Their "discoveries" of "scientific" answers serve no purpose beyond completing school work and so are unlikely to speak to readers who don't have an already-existing affinity for school science. Again, in the hands of a more skilled writer, it is possible that this type of genre could be better exploited.

Ngä Pakanga o ngä Maunga and Poutini räua ko Waitaki

Each series of Tötika stories includes some that are taken from Mäori mythology. For example, *Ngä Pakanga o ngä Maunga* (literally "the battle of the mountains") tells the tale of a jealous quarrel between two North Island mountains (Tongariro and Taranaki) over the love of a third mountain (Pihanga). In his anger Tongariro drove Taranaki westwards and as he fled he cut the deep channel of the Whanganui River. As in the story of Tama-nui-i-te-rä and his two sun-wives, this story accurately describes and links empirically observable features of the landscape with events. (Tongariro and Taranaki are similar types of volcanoes, for example, and Taranaki sits well to the west of a cluster of other central North Island volcanoes.) At the heart of the story are human emotions—jealousy, envy, anger—and a moral that children can intuit.

A Poutini räua ko Waitaki tells the story of a *taniwha* (monster) called Poutini who kidnaps Waitaki, the beautiful wife of a chief, and makes off with her. Pursued by the chief Tamaahua he eventually realises they cannot escape together and lays Waitaki to rest as a boulder of *pounamu* in a freezing river bed. (*Pounamu* is a precious form of jade—or greenstone—found only in river boulders in some parts of the South Island of Aotearoa/New Zealand. The Mäori name for the South Island is Te Wai Pounamu–literally the waters of *pounamu*.) The point of the story does seem to be to account for the origin and distribution of *pounamu* but, because it is told in terms of human motivations and misdeeds, it successfully engages the reader.

These last two stories are more successful as narratives than the others. Unlike the first four, they have all the features of good stories. In addition, they are sophisticated allegorical accounts of the natural world (Biggs, 1994). They express and explain the Mäori worldview and are highly effective as a way of transmitting *mätauranga Mäori.* However, there is a problem (in this context): they aren't science—in conventional terms. With no guidance, what conclusion is the learner supposed to draw from this juxtaposing of two, quite different, knowledge traditions? Are the two systems independent and parallel, or is one "better" than the other? (Cobern & Loving, 2001). (The Teachers' Guide refers to—but glosses over—this difficult question by saying that science knowledge and *mätauranga Mäori* are different knowledge systems, constructed in different ways, for different times and purposes.)

On the other hand, however, the first four stories don't look much like conventional science readers. (Perhaps they belong to some sort of "in-between" genre—"faction" as opposed to fiction?) They introduce science concepts in a more discursive way (and with a lot more descriptive detail) than is usual in science readers. However, they contain far more information than non-science stories. Although they go some way towards providing a bridge between narrative and scientific thinking, we think most children would find it hard to imagine themselves in these stories. They would find it hard to imagine themselves sharing

the purposes and goals of the main characters, and hard to imagine themselves doing what the characters are doing. Thus the stories force children to be spectators, passive observers of the action who are told what to think. While they are a good beginning, these stories don't have the necessary features of good stories, and so they aren't really a success.

Why is this so hard? Does this mean that it isn't possible to develop good science stories? Or that it isn't possible to teach children about *mätauranga Mäori* **and** science? Does all this matter? We think it does, and that there are some important issues at stake here—for science education and for *kura kaupapa Mäori*—as we think about how best to prepare children for life in the Knowledge Age.

Where to from here then?

As we said at the start of this paper, we think that using stories as a way of teaching science is a good idea. We think this idea has some obvious strengths, and some equally obvious limitations. We think we should acknowledge the limitations of the idea and try to think our way around them so we can use its strengths.

As we said earlier, one of the strengths of using stories in science education is that they can be used as a bridge between narrative thinking and the less familiar logico-scientific mode of thinking. However, we need to be clear that the two modes are quite different, and that science "proper" *isn't* stories. This is a key limitation. Understanding science eventually has to involve understanding how scientists think. However, it isn't necessary to do this right at the very beginning. We *could* just use stories to teach science in elementary schools, not in high schools. However, we think that this would be to miss the point. The transition from narrative to logico-scientific thinking has to be scaffolded—otherwise, for most people, it simply won't happen. Science stories are, we think, a good way of doing this scaffolding. However, people *also* need explicit teaching about what it means to "think scientifically"—how it differs from "ordinary", everyday thinking, why it is like this, and what this kind of thinking is *for*. If we see science, not as a body of established and accepted "facts", but as a very particular (and very difficult) way of *thinking*, done for very particular reasons, then *learning* science involves mastering a new kind of thinking, not a set of facts. It is a long slow journey, from one kind of thinking to another. There are many hurdles along the way, and many stopping off points. Seeing stories as one way to lower some of these hurdles allows us to use the strengths of stories while at the same time acknowledging their limitations (in this particular context).

A second strength of using stories to teach science is that they can make it possible for learners to see a place for themselves in science—as active participants, not passive spectators. Good stories engage people's interest. As they are drawn in, people "naturally" think about what they would do in the situation the story's characters are in. They imagine themselves being there, they engage with the characters, and, in so doing, they learn something about themselves—their desires and fears, and their sense of who they are. Most science stories are hard to engage with in this way. Sometimes this is because the people in them seem too different from us "ordinary" people. This can be because we aren't given enough detail about the characters to see them as ordinary people like us (usually because the main focus is on providing "the facts"). Alternatively, it can be because the "characters" aren't people at all–they are abstract concepts (like atoms, genes, or forces) or inanimate objects (like rocks, planets, or chemicals). Because most learners will find it hard to empathise with concepts or objects, and even harder to identify with them, the main lesson they learn from these stories is that science doesn't have a place for them. This is obviously a limitation.

However, most science stories are like this *because* the prevailing view of science is as a body of disembodied facts to be learned. If, instead, we treat science as a way of *thinking*, then it is much easier to see how we could come up with science stories that involve real people (with real feelings and motivations) solving real problems, in ways ordinary people can empathise with. Stories like this *are* likely to engage learners. Once this has happened, it will be relatively easy to move to a discussion of *how* the story's characters actually went about solving the problem (what kinds of thinking they did). Because stories like this allow learners to imagine themselves thinking like a scientist, they can bring them to the point where they are ready to begin to try thinking in this way.

So far, we have been arguing that using stories successfully in science education requires us to take a step back from the conventional view of science as a fixed body of knowledge. We have argued that shifting our focus to a view of science as a way of thinking, or a system of *knowing* makes it easier to see how to use stories productively—while avoiding the pitfalls. This kind of meta-level, "big picture" systems thinking also helps us to think about how to deal with the other important question raised in our discussion of the Tötika stories—the question of how (if at all) to teach *mätauranga Mäori* alongside science in *kura kaupapa Mäori.* Science and *mätauranga Mäori* originate in very different—and conflicting—knowledge traditions. People are at the centre of *mätauranga Mäori* while science, by definition, excludes them. For some in the *kura kaupapa Mäori* movement, science epitomises Western European knowledge and is part of the language of the colonisers. Thus it does not fit with the objectives of the movement and should not be taught. Some might argue that science knowledge (like mathematics knowledge and knowledge of English) is necessary for success in the Päkehä world "outside" *kura*. In the words of the late Mäori leader Sir Apirana Ngata *"E tipu, e rea mö ngä rä o töu ao, ko tö ringa ki te räkau a te Päkehä hei oranga mö tö tinana"* (grow and flourish during your time in this world. With your hand [grasp] the tools of the Päkehä to provide you with physical sustenance).[10]

How then can science be taught so that it *doesn't* displace *mätauranga Mäori* or continue the process of colonisation? One way of dealing with this question is to acknowledge (as the Tötika Teachers' Guide attempts to do) *mätauranga Mäori* as one "way of knowing", and science as another. However, if we *only* do this, we find ourselves squarely in the middle of all the old debates about relativism—which "way of knowing" is "right"? Which is "true"? Which is "best"? We need to find a way out of this trap. One way to do this, we think, is to treat *mätauranga Mäori* **and** science, not as "the facts", but as discourses, *systems* of stories told in particular contexts for particular purposes, that—and this is important—construct *people* in certain ways.

If we do this, then dealing with *mätauranga Mäori* **and** Western science isn't a problem. Having access to two different knowledge systems becomes a resource, an asset—not a problem. Children can learn *about* the different knowledge systems—how they work, what is important in them, and when and where they should be used. However, at the same time they can also learn to see knowledge in the "new" ways they need if they are to participate in the knowledge-based societies of the future. Just as being bilingual makes it easier to understand language as a system (and to learn a third or fourth language), knowing about more than one

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[10] The full text of this quote is: *E tipu, e rea mö ngä rä o töu ao, ko tö ringa ki te räkau a te Päkehä. hei oranga mö tö tinana. Ko tö ngäkau ki ngä taonga a ö tïpuna, hei tikitiki mö tö mahunga. Kö tö wairua ki Te Atua näna nei ngä mea katoa.* (Grow and flourish during your time in this world. With your hand [grasp] the tools of the Päkehä to provide you with physical sustenance. [Open] your heart to the treasures of your ancestors as a topknot for your head. Open your heart to God who is the origin of all things.).

form of knowledge makes it easier to understand knowledge as a series of *systems*, and to learn to think in the kind of "systems"—or "big picture"—ways needed in the new "knowledge workers".

Exploring the strengths and limitations of the Tötika stories in these ways has led us to think about new and different ways of using stories to teach science. Recently we have started work on a new project exploring the use of the digital storytelling methodology[11] in science classrooms. We plan to develop, trial, and evaluate a programme that involves students working in teams on a research project they have designed, and presenting the results of this investigation via a digital story. This, it seems to us, offers exciting possibilities for learners to construct their own science stories—while also developing the understanding of knowledge they need for successful participation in the Knowledge Age. It remains to be seen how well this idea works.

[11] Digital Storytelling was developed in the early 1990s by a group of media artists, designers, and community arts activists in the San Francisco Bay Area, as a way of allowing ordinary people to tell their stories and publish them on the web. See Lambert (2002) or Center for Digital Storytelling (2003a,b,c) for more information.

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