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science education a vehicle for the key competencies in praxis

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'Key Competencies' is one of the primary elements of the 2007 New Zealand Curriculum (Ministry of Education, 2007). In anticipation of the Curriculum being fully implemented this year, the Ministry of Education took steps to inform teachers about the Key Competencies and to ensure they understood their intention, meaning and purpose. In addition, much has been written to better explain what, how and why the Key Competencies are central to both student learning and teacher practice (Barker, 2009; Foster, 2009; Hipkins, 2006, 2007; Hipkins, Roberts, & Bolstad, 2007; Reid, 2006; Rutherford, 2005). At the same time, however, this research has highlighted difficulties relating to the use of the Competencies in New Zealand classrooms. While commenting on science teaching in the 2007 Curriculum, for instance, Barker (2009) identified three 'crucial' issues concerning the Key Competencies: definition, relevance and assessment. This paper addresses these three concerns through an account of one teacher's efforts to understand how to integrate the Key Competencies into her classroom practice.

The Key Competencies

The Key Competencies are defined on pages 12 and 13 of the curriculum document. In addition, the Ministry of Education has created a rich and meaningful website (http://keycompetencies.tki.org.nz/) to aid their understanding and implementation. The difficulties arise, however, with the application of Key Competencies. Although the New Zealand Curriculum is targeted to a nationwide audience, the individual teacher is ultimately the one who has to implement it in the classroom. Many of these teachers now find themselves in the position of having to learn the new curriculum while delivering an integrated approach to teaching. In response, a number of teachers have approached tertiary providers for support in interpreting the new curriculum and to establish ways of incorporating the Key Competencies into classroom practice.

The East Coast of the North Island has a significant Māori population, and one of the region's local tertiary providers was founded on a social justice basis to provide educational opportunities specific to local Māori. Reid (2006) stated that social justice, with regard to equity in education, is best supported by holistic approaches to teaching. Holistic methods can work to negate the selection of knowledge that marginalizes one or more groups for the benefit of a larger dominant group. The teacher discussed in this paper wanted to develop the Key Competencies through content her students would find to be relevant, useful and meaningful and not necessarily what someone else, somewhere else deemed appropriate. This in turn addresses Barker's (2009) concern about the relevance of the Key Competencies.

Hipkins (2007) suggests that assessment of the Key Competencies should focus on strengthening, rather than measuring, student ability. Students need opportunities to connect what they already know to what they are currently experiencing, so as to be able to build the skills necessary to "practise, persist, and overcome obstacles to immediate learning success" (Hipkins, 2007, p.4). Put simply, what teacher, parent or employer would not be satisfied with a student who can demonstrate that they are able to: think; relate to others; use symbols, languages and text; manage self; and participate and contribute in an authentic learning environment they are then capable of translating into the wider world. Science is one way of presenting authentic and meaningful learning environments. In fact, the rest of this paper is an example of how science might be one of the best ways. Specifically, this is an example of a rich learning experience which successfully engaged and enlarged students' competencies.

Electric circuits/Microwaves/Personal Safety: A practical demonstration

During Term 3, August 2009, a teacher at a small, low decile urban school on the East Coast invited an instructor from a local initial teacher education institution to conduct a practical demonstration for her combined Year 4-6 class. Specifically, in addition to using traditional pedagogies, this initial teacher education provider was asked to demonstrate a student-centred lesson drawing on the students' own experiences to integrate the Key Competencies into a relevant, useful and meaningful teaching and learning environment (Macfarlane, Glynn, Penetito & Bateman, 2008; Otrell-Cass, Cowie & Glynn, 2009; Sexton, 2008).

In 2009, 99% (79 of 80) of students and 100% (6 of 6) of teachers at the school self-identified as Māori. The school unofficially operates as bilingual, with many of the classroom interactions switching back and forth between English and Te Reo Māori. As it is classified as an English-medium institution, the school is required to deliver the New Zealand Curriculum. Nevertheless, the legal framework of the Curriculum enables the school to draw on the Māori kaupapa (philosophy, purpose, agenda) of ako (reciprocal teaching and learning) and whānaungatanga (relationships, family kinship). A number of adult helpers are available to support smaller working groups within the classroom. As the class is a combined Year 4-6, older students are paired with younger students in tuakana/teina (older sibling/younger sibling) relationships within their own classroom. The classroom environment is rich in colour and texture and contains personalised items from each student's home. The students address their teachers as kōkā/whaea (foster mother/aunt) or matua (uncle or father) as many are in fact related.

The content for the demonstration session was developed in response to an event that occurred during the previous week, where a teacher inadvertently left a spoon in the bowl of soup she was heating. The microwave had only been in operation for a few seconds when sparking was noticed. Another teacher unplugged the microwave and the bowl and spoon were removed before any real damage occurred. As this caused a great deal of excitement (mainly owing to the fact the student helpers in the staffroom exaggerated the event to the rest of the school) it was decided that an electric circuit/microwave/safety session would be relevant, useful and meaningful to the students.

All of the students had had previous experience with microwaves and an idea of what their function was. When the class was asked 'what is a microwave?' The students generated a short list of what microwaves do: 'heat food', 'cook food faster than the oven', 'warm up food' and, as the previous week's event revealed, 'make sparks'. The students were not asked to explain how a microwave operates or why it can 'make sparks'. The children do not need to know the physics behind what happens. They need an age-appropriate understanding of what happens when different items are placed in a microwave.

The twenty-eight students were organised into their five pre-existing mixed age and ability co-operative working groups and seated at their work stations. Each station had a battery, two wires and a light bulb. The stations were told they had two minutes to get their light bulb to stay on and, after two minutes, only two stations had managed to do this. These two groups were then asked to show the other stations what they had done so all the groups could get their light bulbs working. The resulting discussion between the groups focused on why the light bulbs had worked and what the other three groups needed to do to achieve the same. The three groups then reported back on what they had done differently that made their light bulb work. These discussions were recorded by the teacher in diagram form on the whiteboard. As a result, the students gained a basic understanding of circuits: a power source (battery) connects (using wires) energy from the source to an object (light bulb) and this generates an effect. In this case, the effects on the light bulbs were light and heat. The students commented that the longer they held the circuit together the warmer the light bulb became.

The groups were called back onto the mat to work as a whole class. A microwave (turning plate removed) was placed in front with a no-go semi-circle (a chalk line drawn on the mat) drawn around it to indicate to the students that they could not cross this line. A slight rearrangement allowed all students to view the inside of the compartment. Various objects were placed next to the microwave: a bar of soap, two plates of five red grapes sliced nearly in two and laid out, a light bulb in a glass of water, and two CDs.

The students were asked three questions based on the diagram of the circuit drawn on the whiteboard: 'what is the power source for the microwave?'; 'what connects the microwave to the power source?' and 'what effect will this have?' All three questions resulted in nearly everyone raising a hand to respond. Their responses were written up on a teaching board situated next to the microwave. The first question resulted in most stating the wall-plug was the source of the power. Three of the senior students responded the electricity in the wall was the source as the wall-plug had be to turned on for the microwave to work. The second question had everyone stating that the cord connected the microwave to the power source. The third question resulted in a list of ideas: light, heat, sound, cooking, and one boy asking if they were going to see sparks.

Before each item was placed in the microwave, the students first discussed amongst themselves what they thought would happen. Each item was then placed in the microwave. None of the students predicted the soap would expand into a 'blob' and that it would then remain in that shape even as it was passed around after it cooled. There was no attempt to try and explain that the gas bubbles inside the soap expanded and that this caused the soap to change shape accordingly. The idea was to show the students that the microwave has different effects on different items. The soap was used later to clean hands before lunch.

The grapes were then placed inside the microwave. Some of the senior students thought the water in the grapes would bubble or the grapes would explode like an egg does. Two plates were used to demonstrate what would happen as this effect occurs quickly. The first plate showed what happened and the second plate enabled the effect to be seen again, now that they knew that a few sparks were emitted before the grapes began to bubble and the microwave was stopped. When asked why the grapes made sparks, the students were informed that they would be asked that exact question in a few minutes.

The light bulb in a glass (half-filled with water so that the metal component was submerged) was placed in the microwave with the turntable now in place. Most said that the light bulb would turn on because that is what light bulbs do. They had not expected the light bulb to glow bright and fade as it travelled around the microwave. None seemed to grasp the idea that different points within the microwave could provide more energy to the light bulb than others. They were asked, 'have you ever heated up food in a microwave and found some parts hot, some warm and some still cold?' This generated a loud discussion involving several members of the class at once. The microwave was turned off and the class quickly settled. The students were then given the opportunity to discuss why the light bulb would go bright and then fade and then go bright again as it travelled around the microwave. This resulted in some of the students referring to the diagram and asking how the light bulb worked without any wires connected to it. The students were asked to explain, 'why the grapes begin to bubble?' They eventually got around to the idea that the water in the grapes had heated to boiling point. However, after it was pointed out that no wires touched the grapes, they were then asked, 'but you were asked before about heating food up in a microwave and some parts not being hot and some parts hot, so does the inside of the microwave heat up like an oven or are some parts colder?' This led to the students discussing the similarities and differences between ovens and microwaves, and they concluded that the oven's inside is all hot but a microwave's is not. So they were then asked, 'as the light bulb moves from a hot spot to a cold spot, could the energy from the hot spot make it glow but then not be enough to make the bulb glow when it is in a cold spot?' This discussion resulted in several of the students accepting this point and then encouraging the others to accept it as a CD was picked up.

As the students were told the CDs were included so that there would be sparks, all predicted that this would be the case. They were asked, 'why are there two CDs?' Most responded that this was so there would be lots of sparks. They were then reminded of the two plates of grapes. Three students then proposed that the CDs would spark very quickly like the grapes, and there were two so they would know what to expect the second time. The first CD was placed in the microwave with the turning plate removed and the microwave was turned on for approximately four seconds to generate sparks before causing the plastic to burn. Once again the students discussed what happened and they examined the CD after it cooled. A second CD was 'sparked' to ensure everyone was able to observe the effect. The students were then reminded that they would be asked to explain why the grapes sparked. They discussed the matter in groups with those sitting around them. After a few minutes, one group of four decided that, as the CDs sparked due to the metal inside them then there must be some kind of metal in the grapes. This was not generally accepted until one of the group's members reminded the class of a healthy food unit on vitamins and minerals they had taken at the beginning of the year and proposed that it must be the minerals in the grapes that make them spark when in a microwave. Most of the class accepted her answer.

The final question was, 'so who thinks they can tell the class what happened last week in the staff room?' Nearly half the class's hands went up. During the discussion that followed, the students explained that the metal spoon sparked like the grapes and CDs. They concluded that if the microwave had stayed on longer the sparks could have started a fire and this could have caused the school to burn down. This entire session took just over an hour.

The class then went back into their working groups, and each group was asked to illustrate and describe what had happened in one part of the demonstration. In this class the students record their experiences in 'books' they create. The senior students lead the younger ones so that they all participate and contribute to the book. This also gave the classroom teacher and the initial teacher education instructor a chance to discuss what had happened and where to go next. The classroom teacher felt her students needed more opportunities like these to express their 'thinking' about what they were doing and how this connected to what they already knew. Although she knew that her class had problems with written literacy, she was happy about how well and enthusiastically they expressed themselves in oral language. Whānaungatanga, which refers to relationships, is practised daily in the school so the teacher expected the students to be able to demonstrate 'relating to others' and 'managing self'. The teacher liked the idea of the demonstration as it gave the students the opportunity to 'participate and contribute' without having to write down what she referred to as the 'scientific procedure' (title, hypothesis, resources, procedure, observations, and conclusion) she normally utilised. She noted that the students began to contribute more and their depth of insight increased once they realised the science lesson was not the usual process of watching the teacher conduct a brief 'experiment' they would then spend a half-hour writing down.

Final thoughts

This paper addressed the three issues of definition, relevance and assessment that Barker (2009) raised in regard to the New Zealand Curriculum and science education through a practical demonstration of how the Key Competencies can be combined with relevant, useful and meaningful learning experiences to construct an authentic and meaningful learning environment. In particular, the students who participated in the demonstration were given an opportunity to connect what they already knew (about microwaves) to what they were currently exploring (electricity, electric circuits) and to make sense of this new knowledge. To achieve this, they had to participate and contribute by sharing ideas and discussing opinions with each other and the whole class. The initial teacher education instructor kept the discussions relevant, useful and meaningful without having to go into the physics or the chemical changes behind what was happening. At the same time, the students remained engaged and not only excited about what they saw.

By the end of this demonstration, the classroom teacher concluded the students had gained an age-appropriate level of understanding of the dangers of microwaves and what happens when certain items are placed in them. More importantly, one of the four groups was able to connect the session on electricity, microwaves and safety to a healthy food unit that was delivered nearly five months previously. Possibly one of the most important statements came from one Year 5 boy who stated, "So that is why you don't put metal in a microwave, it can start a fire like those commercials on TV and burn down your house". This short statement presents an excellent example of a child being able to connect the content of a classroom demonstration to their personal experience to develop a new and personally significant insight. Rather than the usual edict of 'do not do because I say so', this child gained an understanding of why something should not be done.

Furthermore, the classroom teacher realised that, instead of focusing on science learning, she was able to approach learning from a science context that her students are able relate to. She plans to explore more areas of science to engage students in their learning. In fact, she followed this lesson with further enquires into what happened to the soap and how air expands when heated.

This article demonstrates how science education is a vehicle for the Key Competencies in teaching practice. The students were exposed to activities that surprised and engaged them. They were provided opportunities to explain not only what was happening but also how they understood why it was happening. These activities were deliberately chosen to build upon an event they were already discussing so as to link their home life into school life. As this article has shown, the Key Competencies are about what the teacher and students do as well as what they know.

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