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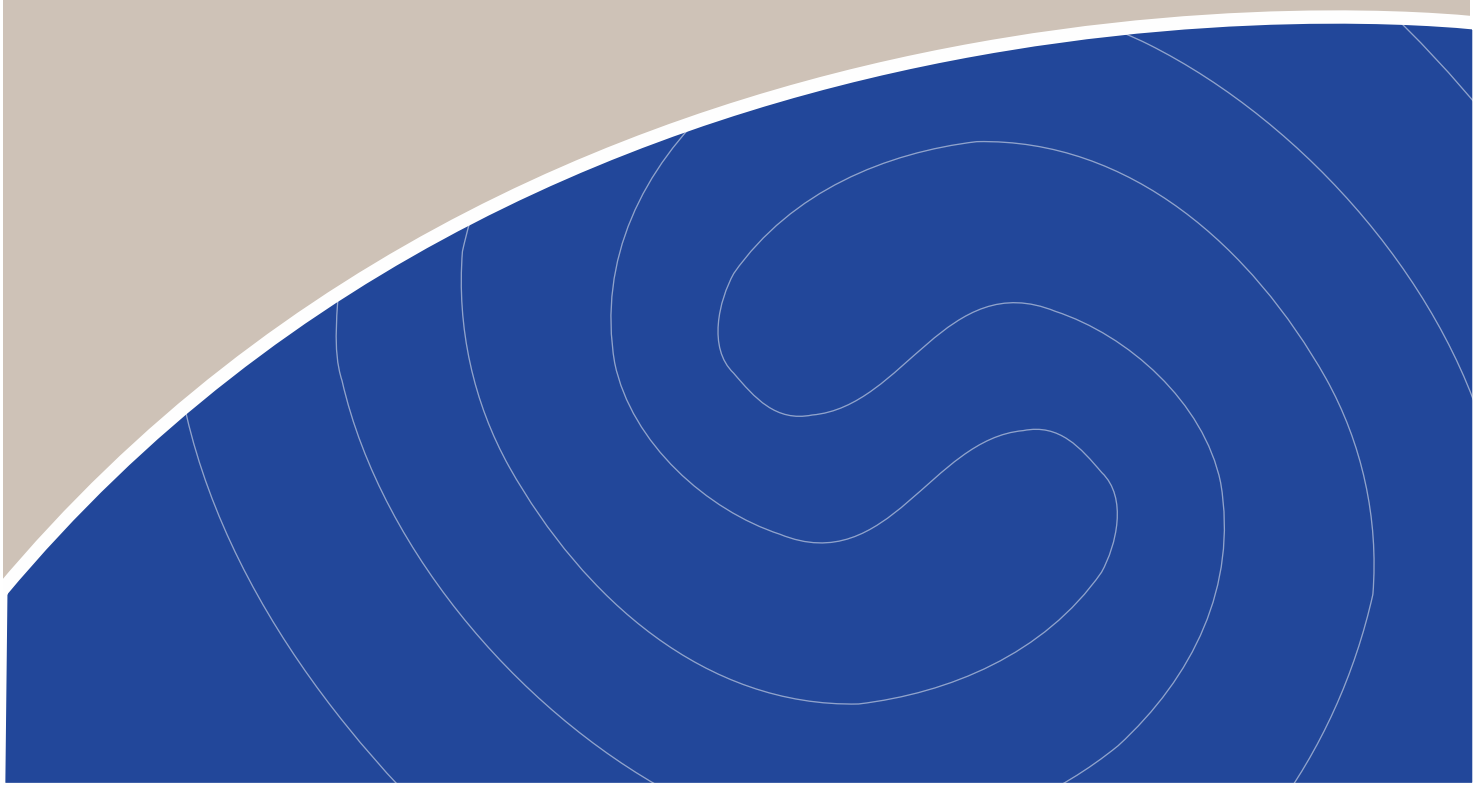
Reflecting on purposes for learning science: Two case studies of support for changing teaching practice

Lorraine Spiller and Rosemary Hipkins



Science in the New Zealand Curriculum

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Report prepared for the Ministry of Education

Lorraine Spiller and Rosemary Hipkins

2013

Research partners

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1. The thinking behind this research

The two case studies described in this short report were devised as one response to the findings of a survey conducted as part of a larger research project to investigate support for science education in New Zealand schools (Hipkins & Hodgen, 2012). The survey found that teachers are relatively less confident about implementing the Nature of Science (NoS) strand of the science curriculum than the more traditional contextual (content) strands. They were least confident overall that they knew how to implement the so-called 'essence statement'—the section of *The New Zealand Curriculum* (NZC) that describes the overall purpose of including science as one of the eight learning areas of the NZC framework. The brief version of this essence statement states that:

> In science, students explore how both the natural physical world and science itself work *so that they can participate as critical, informed, and responsible citizens* in a society in which science plays a significant role. (Ministry of Education, 2007, p.17, emphasis added)

Another working paper from the early stages of the project outlined how the NoS strand could help teachers to change their pedagogy in ways that make it more likely they will achieve the citizenship purpose italicised in the quote above (Hipkins, 2012). However, for this type of outcome to be achieved, teachers need to understand that the intent of the NoS strand is different from straightforward knowledge acquisition. Simply *knowing about* NoS ideas (assuming teachers do have adequate knowledge of these) and being prepared to include them in their classroom curriculum will not be enough to achieve the purposes signalled in the essence statement (Hipkins, in press).

Taken together, the survey results and the working paper raise the question of whether greater support to rethink the *citizenship intent* of the Science learning area, with a focus on the work the NoS strand might do, could lead to substantive change in teachers' practice. The two case studies discussed in this report were devised to put this question to the test.

2. The contexts and conduct of the case studies

Two secondary science teachers were supported by a visiting researcher to think explicitly about their purposes for teaching science and the outcomes they hoped their students would achieve from several units of work. The teachers came from similar low-decile secondary schools in the same community, each with a high enrolment of Māori and Pasifika students. Each teacher was supported through a series of in-depth interviews to reflect on their teaching and planning. The researcher encouraged each teacher to keep the stated intentions of the essence statement in mind as they planned, taught and reflected on their work. They were specifically encouraged to think about the purposes for which they were teaching the current science topic and how what they actually did in the classroom might contribute to those purposes being achieved. The table below summarises the timing and nature of the contact between the researcher and the teachers and their classes.

A brief overview of the research activities and their timing

Date	Teacher 1	Teacher 2
June 2012	Observation of class (the topic was filtration) Interview with teacher	
July 2012	Planning meeting with teacher to discuss current topic (atoms) and to plan next topic (biodiversity)	Initial meeting of teachers, facilitators and principal of 'student voice' project
2 August 2012		Watched video of lesson with student focus group (Earth orbit) Interview with teacher
6 August 2012		Watched video of lesson with student focus group (eclipses) Interview with teacher
20 August 2012		Teachers, facilitators and principal have group meeting Short interview with teacher
21 August 2012	Interview with teacher (follow up on biodiversity topic)	
3 September 2012		Watched video of lesson with student focus group (speed) Interview with teacher
13 September 2012		Watched video of lesson with student focus group (forces) Short interview with teacher

17 September 2012		Watched video of lesson with student focus group (energy) Short interview with teacher
27 September 2012		Final group meeting with teachers, facilitators and principal
14 November 2012	Extensive interview with teacher and another teacher from the science department.	
17 December 2012	Final interview with teacher (discussion about how she felt about support)	

With the support of the researcher, the teachers examined their personal beliefs about and understanding of teaching science. Together they explored strategies that could refocus the teacher's planning and teaching while keeping the NZC statement about the overarching purpose of learning science in mind. Any strategies they agreed to were trialled in the teacher's classroom. The teacher and researcher then reflected on the changes the strategies had made to the structure of the lessons, the classroom teaching and the students' learning. A small group of students discussed their perceptions of the teacher's intended purposes for the learning with the researcher. The researcher subsequently reported these perceptions back to the teacher as feedback on how well the students' perceptions matched the outcomes they had intended.

The teachers were willing to participate in the research because they hoped that their participation would help them to learn more about the intent of the NZC document and, specifically, how they should implement the Nature of Science (NoS) strand. They both knew and trusted the researcher. They were both experienced science teachers, confident in their content knowledge but needing assurance that their interpretation of NZC was what was intended. Both teachers' science departments still used unit plans written some years previously to guide their Year 9 and Year 10 teaching. They felt that being able to focus on the purpose of science as they planned was a good opportunity to update and refresh these unit plans. The case studies were approached in different ways but had a common focus on foregrounding the teacher's thinking about the purpose of science in their Year 9 or 10 science lessons.

The researcher approached Teacher 1 and asked if she could work with her to talk about her planning and together design a new unit of work with the overarching *Curriculum* purpose in mind. The researcher would then observe one of the science classes and talk to a group of students from this class about what they thought the purpose of the lesson was. Teacher 1 agreed, and after the observed lesson the teacher was asked questions about the purpose of the teaching acts that had been observed and how they linked to the lesson plan. The students' responses were conveyed back to the teacher and new strategies developed. Over a 6-month period the researcher supported the teacher with two further strategies and asked the teacher during in-depth interviews about the implementation of these strategies and how her practice had changed (see above table).

The second teacher (Teacher 2) approached the researcher to be a facilitator for a professional learning project taking place in her school. This project had ‘student voice’ as a focus. In this case, the researcher watched a video of the teacher’s science class with a group of students from that class. The researcher questioned the students about various teaching acts they were watching and reported the students’ responses to the teacher. As in the first case study, the teacher and the researcher then discussed the students’ responses and reflected on the purpose for which the science was being taught. The researcher then supported the teacher to develop new strategies for this class. As the table above shows, five lessons were observed over a short time frame (6 weeks).

3. Overview of the results

Each case study is described in more detail in sections 4 and 5. First, however, the results are reported in brief. A discussion of these results follows the case study sections.

At the end of the study there was little evidence that the first teacher's thinking had changed. The researcher was not successful in persuading her that the sorts of changes being discussed could refocus lessons to foreground a different purpose for learning science. Despite willingly discussing new ideas and strategies with the researcher, the teacher remained resolutely focused on successfully getting students through National Certificate of Educational Achievement (NCEA) examinations as her main responsibility as a science teacher. She hoped students would encounter science as interesting and potentially useful for their futures, but her main purpose was to deliver knowledge and content for NCEA examinations and university study. The new strategies they had devised together had value for the teacher because they helped students to *engage* in acquiring knowledge that would ultimately be useful for NCEA.

Regular contact between the second teacher and the researcher over a shorter time period did result in changes in the teacher's practice. The first two lessons were well planned and skilfully executed. Later, when there was less time for joint planning, new strategies were often used at the beginning of a lesson, but unless the teacher had been able to prepare thoroughly for all aspects of the lesson, interruptions or time issues could prompt her to default to tried-and-true teaching practices. At first the second teacher was unsure about how well the suggested strategies and activities would be received by the students, and she was surprised by how well they worked. Students' evident enjoyment and engagement in the lessons quickly dispelled her doubts. The researcher found that often a simple prompt would be sufficient to support the teacher to draw on her existing knowledge and skills to make small but powerful changes that refocused her practice, at least in the early stages of the lesson. However, when the support of the researcher was no longer available or there was not enough time to think through and prepare carefully for every stage of the lesson, and/or other work pressures crowded in, she, too, returned to traditional classroom practice.

4. Case study one

The context

Teacher 1 taught in an urban, mid-sized, decile 5 secondary school. The ethnic mix of the class observed was a more-or-less even division between Māori, Pasifika and Pākehā students. In the science department the topics and lesson plans for Year 9 and 10 were primarily designed to scaffold students into Year 11 science courses that would be assessed for NCEA, and then into the senior sciences of Years 12 and 3. Topic-based units of work were planned around learning content knowledge and skills. Students followed instructions for practical work and for 'doing research'. There was a marked focus on literacy, in line with a school-wide emphasis on literacy across the curriculum.

The intervention

Over a 6-month period from June to November 2012 the researcher investigated Teacher 1's planning and delivery of three lessons to a Year 9 science class. Altogether there were four interviews with this teacher. In one of these interviews another science teacher in the same science department was also included. Each of the three focus classes was observed by the researcher. During and after the observed lesson some of the students were asked what they thought the teacher wanted them to learn and why the teacher might think that was important. At the end of the lesson the teacher was also asked why she had decided to approach the lesson as she did, what she most wanted the students to know as a result of the lesson and why she thought that was important. During the debriefing session the teacher was told about the students' responses to the lesson. Finally, she was encouraged to reflect on the lesson and the changes she would make for future lessons.

Five weeks after the first set of conversations and classroom observation the teacher and the researcher discussed the teacher's reflections and thinking during the teaching of the second topic, which was the structure of atoms. The teacher believed this topic was inherently interesting for students and she was reluctant to refocus the purposes for learning science that she already valued. From her point of view, the purposes for learning about atoms were already being achieved. She liked the unit plan and the way the topic had been taught in the past. She saw the content of the unit as an important step towards learning for NCEA examinations. The teacher said the students were already engaged in the traditional learning tasks of the unit so she saw no need to change her practice. The assessment already attached to this unit of work was based on the knowledge recall modelled in the relevant NCEA achievement standard, and this assessment seemed to predetermine all the teaching that took place.

In an attempt to refocus the teacher's thinking on the purposes for learning science specified in NZC, the researcher and the teacher together looked at the assessment in the next unit, which was on biodiversity. This topic was to be assessed as student research, which the teacher said was usually poorly done by her students. Because of this she was willing to develop new strategies. The third teacher interview followed the end of this topic. In this interview the teacher reported that the research strategy she and the researcher had devised together had been very successful. She had even shared her success and strategy with other science teachers in the department. A fourth interview followed 3 months later, when another science colleague in the same department discussed his assessment of the research strategy.

The first lesson (filtration)

In this lesson the teacher began with a short data show presentation about filters. She discussed how the word 'filter' is used scientifically and in everyday language. The students then followed a set of instructions to separate sand from water using filter paper. The lesson ended by looking at one real-life filtration system and other examples of situations where filters are useful.

Students were engaged in the lesson and understood the basic content. When they were asked, "What do you think your teacher wants you to learn?", they gave answers such as:

> What can and cannot dissolve and new words.
>
> She wants us to know the process.
>
> How to make clear water.
>
> How to separate substances.
>
> Science words and where to use them.
>
> What we can filter. What things are soluble and insoluble in water?

However, when they were asked *why* the teacher might think knowing these things was important for them they were less sure. Two students said they did not know. The reasons others gave were either very vague, assessment focused, or in one case referred to a television adventure context which the teacher had used as an example:

> Words can help us in our science in upcoming tests.
>
> For learning.
>
> So we know how things work in the world.
>
> In the wild we can get clear water.

When asked, "Why do *you* need to know these things?" students could see some relevance, but again their reasons tended to relate to vague, unspecified future benefits:

> Things that are important in life.
>
> Use skills later in life, for example in the ocean.
>
> Helps me if I get lost or something.

So we know about the water we are drinking.

So we know what to do in the future.

The teacher said that she was pleased with the lesson and the students' responses. Because most of these students were broadly learning at curriculum Level 2 or 3 (rather than Level 4 or 5, which would be more typical for their age group), she believed that the learning focus needed to be on scientific literacy.[1] The students' responses showed that they were aware of the emphasis on new vocabulary. Their other responses showed that the teacher had been successful in making the content relevant and engaging. However, when responding to the researcher's questions about why filtering might be important to teach and learn, and specifically why the students might need to know about this, the teacher was not able to create specific links between the learning focus and students' lives:

> I struggle with that because I have been teaching for such a long time and knowing that next week I have a problem solving task [separating sand, salt and iron] and they need this.
>
> It is a key competency skill. It is a thinking skill and a problem-solving task. I want them to think in a group, plan out a scientific investigation. I think the fact that you can follow steps—follow through like a maths problem.

These comments suggest that the teacher's intent—notwithstanding the conversations she had had with the researcher—remained firmly on building students' knowledge and skills via conventional pedagogies. There is a tension in the second comment between her desire to have students think for themselves and the provision of steps to follow so that they "did not founder in their planning".

The teacher did try to make the lesson relevant to everyday life. She had worked hard to achieve this with examples of filtration systems and with descriptions of situations where clean water could be needed. But when asked if there was anything she would change about how the lesson had unfolded, her only suggestion was to change the order in which she introduced ideas and activities. The lack of *specific* connections students made to their own lives was not something she saw as problematic.

The teacher admitted that she was uncomfortable with the researcher's questions about what she thought the purpose of science was. She knew she saw the purpose of teaching science as passing examinations but she felt there was something else that she should be thinking:

> Just teaching as always for exams.
>
> I know what you are asking but I can't answer any other way.

---

[1] In line with the school's focus on literacy across the curriculum, this appeared to mean "literacy in the context of science"

In an effort to support her to think more critically about purposes other than summative assessment for learning science, the researcher suggested that they think together about some of the other assessments the science department used with their junior classes. The teacher revealed how a previous knowledge-based test on matter had proved difficult for one of her classes to pass. She had allowed her students to draw flow diagrams about the topic, which they could take into the test. However, she called these "cheat sheets" and clearly did not feel that this was an acceptable way to assess her students' learning within the established regime of common year-level topic tests. She was mindful that any scaffolding she provided for her class might be seen by the other teachers as dumbing down the assessment in comparison with the unprompted recall they expected from their own students.

Prompted by the researcher, the teacher did agree that in this assessment the students had still needed to interpret the question and source the relevant information from their flow diagrams. She conceded that this was perhaps a better assessment task than simply recalling knowledge. After this conversation the teacher agreed to look at the assessment criteria for future topics and to investigate the possibility of focusing her next units on an overarching question that anchored the intended learning to students' lives and experiences.

The second lesson (atoms)

During this unit of work students learnt how to draw atomic diagrams, define elements, compounds and molecules and write simple chemical equations. For the teacher this learning was important because it was needed in Year 11 assessment and beyond. However, as the third of the comments that follow shows, she also had in mind the potential for this new knowledge to be interesting for its own sake:

> It is important because it's in our science course and we need it in Year 11. It's part of our examination and it's relevant to us because we need to know what's in the world around us and what elements make up our world.
>
> I think what we teach here is to prepare some of them for university and they need this information. Some of them may leave school at 16 and may never see this again and others in courses such as hairdressing and building may need this knowledge and be able to apply it.
>
> For me it is learning new things. This is something new. Most of them had never seen a periodic table before. Most of them had seen the circles around an atom on TV but did not know what it meant. It's recognising things and that there is a meaning for them e.g., H_2O.

This teacher, together with her colleague interviewed later in the research, was so focused on NCEA achievement that junior classes were taught some of the same content as senior classes in the belief that better understanding comes with repetition:

> We are getting the building blocks ready for the next things we teach. We want to scaffold the learning so that at Year 10 or 11 things begin to make more sense.

If and when students show that they understand these ideas at Year 11, the teachers' thinking that determines the junior course structure is reaffirmed:

> My Year 11 students were revising this and they didn't need me so it emphasised that we are happy at Year 9 and 10 to do this. Even low-level kids were quite happy to sit there and do electron arrangements.

So firmly held was this assessment-focused thinking that the teacher did not see any good reason to shift any aspect of her traditional pedagogy for the unit. She was interested in change if it would lead to greater engagement, but from her point of view this unit was already engaging and successful. The students were not observed because there was no change of focus to explore.

The third lesson (ecology)

In another attempt to refocus Teacher 1's thinking on NZC'*s stated* purposes for learning science, the researcher used the criteria for the next topic's assessment to revisit the lesson plans. The researcher's aim was to put the emphasis of the conversation on what the teacher thought it would be important for the students to know, thus moving the primary focus away from recalling knowledge for NCEA assessment.

Previously the assessment of this unit had involved the students in researching the habitat and lifestyle of an animal and presenting their findings on a poster. The assessment criteria included demonstrating knowledge of specific biological terms such as 'habitat', 'adaptations' and 'food webs'. However, in the past, teachers had found that students often downloaded information from the Internet and completed the task without further processing. Many other students did not complete the task at all. Dissatisfaction with this past experience appeared to help open up space for new teaching and learning approaches to be considered.

Together the researcher and the teacher developed a new strategy. The teacher would teach information about the biological terms (one per lesson) and students would find out how that specific biological concept applied to their chosen animal. They would then explain why the ideas/activities/relationships in focus might be important for this specific animal. Students would put the information in a booklet. An overarching question would be, "What would happen to your animal if something changed in its environment?" They could choose any change, such as a flood or clearing the forest for mining. The teacher sent students to the library to collect information on their animal and then worked with them as outlined.

Taking this scaffolded, but still open, approach the teacher found that student engagement increased markedly. The completion rate was over 80 percent. This success rate then encouraged other teachers in the department to trial the strategy.

Teachers talk about purposes for learning science

Once all the teachers had completed the unit, three of them discussed with the researcher how they had used the new format. One teacher had developed a table with headings to match

definitions and examples. Another had scaffolded students' learning by making work sheets which students applied to their chosen animal. For example, one work sheet provided a range of potential habitats and asked, "Looking at these habitats, where would you place your animal?" This teacher later used a similar format in another topic. Students were to produce a medical pamphlet that discussed disease and treatments related to respiration.

Despite increased student engagement, one of the teachers said he still felt as if the lessons were simply repeating information. However, when asked how the students answered the applied question about what would happen to their animal if something changed in their environment, he said he had not known about this part of the strategy. The case study teacher did not use this refinement proposed by the researcher because she thought the applied question would be too difficult for her class to tackle. Nor had she shared this specific idea with her colleagues because she saw it as an extra; i.e., knowledge not necessarily needed to move on to subsequent topics in ecology. She noted, "That could be an extension question".

However the biology teacher in the group, who was searching for a sharper focus for the unit, could immediately see the possibilities for this additional step:

> I don't think of it as an extension but as a context to build the whole topic around. It could make your ecology assignment [be focused on] global warming. So the water is going to rise, so here is your animal. Given that this is his habitat, what impact is the water rising going to have?

In this conversation this biology teacher, who was less experienced than his colleagues, seemed willing to rethink the purposes of his teaching and to search for more meaningful learning experiences for his students. With more time and support he would perhaps have been open to the shift of focus the researcher was seeking. He did have the space and freedom to experiment with his pedagogy and he was interested in doing so. Indeed, Teacher 1 actively encouraged him to take the lead in bringing new ideas to the team. His major constraint, however, was the common schedule of topic tests for the end of each unit and the strongly shared view of the team that passing assessments was the main purpose for learning.

What was achieved overall?

Teacher 1 agreed to participate in this case study because she felt the need to review her science department's unit plans and schemes. However, both she and the other teacher cited above said that they were basically happy with the content in their lessons. *How* they teach was what they actually wanted to review. The less experienced teacher made the following comments, but Teacher 1 agreed with him:

> It's more about how we teach. We have looked at what we teach and it is quite robust at the moment. We have looked at our Year 11 topics very carefully and we need to work backwards from that. It has to be [driven by NCEA].

> What I want to do is pull out the unit plans and put them on sheets of paper and spend 20 minutes going round discussing [with other teachers in the department] what bits work well and getting feedback.

Teacher 1 wanted new ideas for her practice but her interest was in making changes to the teaching of existing topics, which would be retained. New strategies suggested by the researcher were not sufficient to convince her to rethink purposes for learning, which in turn might help to trigger other sorts of important changes. For Teacher 1, passing the NCEA examinations was and still is the main purpose of teaching science. *How* she teaches matters mostly for engaging students so that they successfully acquire the content needed for assessment. Both teachers were willing to change assessments to give them a sharper, more engaging focus, but essentially they were still looking for knowledge recall rather than other types of learning outcomes. They clearly needed much more time and support to think through the ways in which knowledge could be both *used* and *demonstrated* if other purposes for learning were in the foreground.

5. Case study two

The context

Teacher 2 taught in an urban secondary school with a decile 1 rating. Around 70 percent of students in this school identified as Pasifika. As in the first school, the topics and unit plans for the Year 9 and Year 10 science classes in this school had been used for many years and the teacher taught them well, if traditionally.

The intervention

The school had recently invited teachers to participate in a professional learning programme centred on the concept of student voice. Three teachers volunteered to explore ways to give students a greater say in their learning. Each asked a facilitator to participate as their support person throughout the programme. The researcher agreed to be the support person for the science teacher who had volunteered. She (the researcher) welcomed this as a second opportunity to support a teacher to plan and teach with a more explicit focus on the purposes for which students were engaging with science.

Four discussions were held between the principal, the four teachers and the four facilitators, one of whom was the case study researcher. Four sets of student objectives and three sets of teacher objectives for the initiative were developed by this group. The student objectives were to:

- develop the capacity of the students to identify and articulate how they learn best
- develop their ability to evaluate and reflect on their learning
- feed back/feed forward to their peers and staff at a later date
- feed back to the facilitator with respectful dialogue.

The teacher objectives were to:

- be open to learning from the learning conversations that happened between teacher and facilitator
- be willing to improve/adapt/tweak teaching in the light of conversations with the facilitator
- be willing to disseminate and share professional learning with other school staff.

Each teacher chose a Year 9 or Year 10 class and a group of four students as the focus group. The students were selected according to their willingness to participate in the study, and had to have

good communication skills and a good attendance record. The idea, for all four participants, was to video specific lessons which their colleague in the project would then review with the student focus group. The colleague would act as a critical friend, taking the feedback from the students to the teacher. The researcher noted, however, that the focus of feedback for the other three teachers tended to be classroom management. Teacher 2 was a very good teacher and did not need this sort of feedback. She was interested in changing her practice in more profound ways.

The researcher and the focus group students together observed five videoed lessons from the science teacher's class. The first of these lessons was in early August and the final one was in mid-September 2012. After this joint review and discussion the researcher met and discussed the students' responses with the teacher. During this conversation the researcher and teacher also discussed the intended purpose of the lesson and how the science being taught contributed to developing that purpose. After each discussion the teacher and the researcher developed new strategies for the teacher to try with the class.

The first lesson (planet Earth)

This lesson focused on the Earth's orbit and tilt and the relationship between these features and the seasons. Learning activities included student discussions in small groups, class discussions, a reading task followed by teacher questioning, and role play. Through all a small number of students sat quietly and took notes. These students did not contribute to the discussions or the role plays, while not noticeably opting out. However, three of the four students in the focus group admitted that they were pretending to participate in one of the activities.

The focus group students said they enjoyed all the activities in this lesson. However, three of them said they did not understand the reading task and waited for the teacher to give them the answers. (This reading described differing perceptions about the orbit of the Earth and its relationship to the Sun.) The students saw waiting as an acceptable response to the challenging reading, but they were aware that some class members always waited for the right answers and they felt this was a sign of laziness and unfair on the teacher. They said that students "should at least try". They held the teacher in high regard and were aware that she wanted them to achieve. All four students appreciated that they could ask her for help at any time and she would always respond to them positively, while encouraging them to find a solution themselves.

> She doesn't tell us the answer but hints.

Even though the students were largely content with the lesson, the teacher was ready to change her practice. She told the researcher:

> I want to throw everything out and start again.

She said she wanted to start by looking at how to get *all* her students learning, and recognising that they *are* learning. With this aim in mind, the researcher and teacher discussed possible ways to refocus the purpose for the lesson as a whole and each of the tasks within the overarching

purpose. During this conversation the teacher decided that the reading task could be refocused to support students to understand how scientists have built their knowledge about the relationship between the Earth and its orbit. The teacher then developed a lesson for the next day with this purpose in mind.

The second lesson (eclipses)

During the second videoed lesson students were shown two videos. The first video showed a group of people (not scientists) watching a solar eclipse and the second video showed people watching a lunar eclipse. Responses to these events, including ideas the people shared with each other about what might have caused them, were captured in the short filmed episodes. Students were asked what the people in the video had seen and what their observations had led them to think. A class discussion followed, and the various comments were recorded on the whiteboard. The class then decided which of these comments would be considered evidence (i.e., observed details of the phenomena they had just witnessed along with the people in the video clips) and which would be considered inferences. Students were then asked to discuss whether scientists would use evidence or inference, or both, to explain their ideas about the cause of eclipses. Students were then asked to think of five personal questions they would want answered from this task.

The researcher noted that the teacher had created this task on the basis of a very short conversation about the importance of learning how to differentiate between observation and inference. Seeding the in-principle idea had been sufficient to unleash her creativity. The researcher was as interested as the students in the engaging and interactive lesson she devised. The focus group students were animated and engaged both in the lesson and in the focus group discussion. They easily articulated their learning and questions about eclipses. They also spoke positively about the changed balance between discussion and more formal writing activities.

Encouraging students to talk about what they are learning and about their learning experiences was a school-wide focus, based on Guy Claxton's 'learning to learn' pedagogies (see, for example, Claxton, 2008). The teacher said she had combined this learning-to-learn focus with the Understanding about Science sub-strand of the NoS strand of NZC.[2] In this lesson she changed her teaching strategies in two ways:

- she stopped "telling the students what to learn"
- she allowed the students to "work like scientists".

Teacher 2 explained that she would usually micro-manage this particular lesson (which she had taught a number of times) by stopping the video at various points to explain what was happening. She would typically finish the lesson by outlining the scientists' explanations for eclipses. This

[2] This is one of four sub-strands of the overarching Nature of Science (NoS) strand.

time she let each video run without interruption and allowed the students to use their own understanding to develop questions for research. However, despite the students' obvious engagement with the learning activities, she had found it very difficult to relinquish control of what the students were actually learning.

Looking ahead to the next observed lesson, the teacher and researcher discussed what the achievement objectives described in the 'Communicating in science' sub-strand of NoS might look like.[3] Although the teacher developed her next lesson around one of these achievement objectives, she said she was still unsure what 'Communicating in science' actually means.

The third lesson (graphing motion)

The teacher introduced this lesson by telling a story about the journey of a snail. The students were then asked to describe the journey in a drawing, in the quickest way they could think of. Students variously used timelines, cartoon strips, arrows and lines to describe the journey. The teacher then gave the students a graph of the snail's journey and asked them to compare the graph with their own drawing. Students were asked to take specific note of how the journey was communicated: the axes, the shape of the graph from the points plotted, etc. The teacher said she wanted the students to understand that scientists use graphs to represent motion in a specific way that is faster and more accurate to communicate than their own various representations. The lesson finished with the teacher asking the students what they had learnt, including what they had learnt about themselves as a learner.

The students were again animated and engaged in this lesson and were easily able to articulate how scientists use graphs to depict speed. They had also noticed that their previous comments about the pace of activities had been acted on. They liked the faster pace, the conversations about learning (not just about content) and the sharper learning focus that both of these changes conferred.

Despite this positive feedback, the teacher was unsure whether the lesson had met the intent of NZC. She was aware that the students were more engaged in the lesson than usual, but she could not articulate clearly what she had wanted the lesson to achieve, and hence the students to learn. Her uncertainty about the meaning of the 'Communicating in science' achievement objective appeared to be behind these doubts, and the evident success of the lesson she had so creatively devised was not sufficient to allay her concerns.

The fourth and fifth lessons (forces and energy)

The fourth lesson explored forces, using role play to examine balanced and unbalanced forces. The fifth lesson involved matching pictures illustrating different types of energy to their definitions. Both were traditional lessons with a focus on the transmission of science content. The

[3] This is another of the sub-strand of the NoS strand of NZC.

teacher had not made any changes to her previous year's lesson plans. She said that the fourth lesson was a revision lesson and that she had to abandon her planned innovation in the fifth lesson because of technical problems.

Students were disengaged in both these lessons. However, in contrast to the earlier lessons, the focus group students could not say what the lessons were about or what learning was expected.

Reflecting on the student voice initiative as a whole

The student objectives for this initiative were met—at least in the first three lessons. The students were able to explain how specific things the teacher did had helped them to learn. They found it helpful to have more explicit expectations about what they were expected to achieve in a lesson. They appreciated pacing that helped them keep to time so that they were able to complete all the tasks. They enjoyed the use of practical activities, slide shows and videos as discussion starters. They said they trusted the teacher to get them through the work they needed to learn and they noted that their feedback had quickly resulted in changes in the teacher's practice. They were able to compare and give examples of activities they had experienced in this class and in other classes. However, they considered this teacher to be their best teacher so they had no experience of any better learning to bring to their critique.

The teacher also met her objectives of being open to change and willing to try ideas. Conversations with the researcher helped her express her desire to make changes. With immediate support to hand she was able to refocus her lesson plans and teaching practice. At the time of each conversation, and for the lesson immediately following, she was able to articulate purposes for the science she was teaching that went beyond content acquisition for its own sake. However, maintaining these changes was clearly difficult when there was less immediate contact with the researcher.

For her part, the researcher noted the large impact that was possible from rather small changes in practice. With what seemed to her to be minor adjustments and refocusing, the teacher was able to transform the learning environment in the class. Her pedagogical skills were finely honed, and once she and the researcher had decided in principle how to adjust the lesson this teacher did not need any further practical help to bring those plans to fruition. This relatively brief intervention was, however, by no means sufficient to engage the teacher in *sustainable* change.

Maintaining her finely honed management strategies depended, at least in part, on her ability to think through and anticipate, in detail, all aspects of the lesson she was about to teach. When other priorities claimed her attention, this thorough anticipatory planning could not be done. When armed only with a more sketchy vision of the unfolding learning action, the teacher could still *begin* as planned, but any interruption or unanticipated event would see her quickly revert to tried-and-true practice.

6. Concluding comments

These two case studies highlight and confirm the significant challenges involved in supporting changes in teacher practice. These challenges are already well known so this overall comment is not particularly surprising. However, the case studies, together and in contrast, do contribute several important insights with important implications for policy and practice.

Perhaps the most noteworthy finding is that a sincere desire to change practice, *even if* followed up with strategic and purposeful experimentation with change, may not of itself be enough to generate sustainable change. Once the immediate support for Teacher 2 was withdrawn her practice quickly reverted to more traditional pedagogy. This happened *despite* her desire for change *and* the positive, receptive response of the students to the changes she made. Student engagement is important to teachers, so this positive feedback could have acted to confirm the new approaches and trigger further change. But it did not. Why? This is a troubling question for those who work with teachers to change and, more importantly, sustain change in their pedagogy.

At least a partial answer can be seen in the *timing* of Teacher 2's switch from innovation to the tried and true. She could begin lessons with inspired changes, but unless she had been able to think right through the whole lesson sequence (which needs considerable time and often some critical input), she could not sustain the innovation if anything happened to divert her attention. With this proviso in mind, Teacher 2's continuing uncertainty about some aspects of the overall purpose, look and feel of the changes she was supported to make when weaving a NoS focus into the intended learning needs further careful consideration.

It was not that she could not appropriately enact the type of learning suggested by the researcher. She did that very well. Rather, the stumbling block seemed to come from her uncertainty about what the refocused outcomes actually *meant* in terms of the unfolding learning action. Highly responsive teachers must always improvise to some degree and critical questions guide their decisions as they do so. In this change context such critical questions might be:

- What should NoS (re)focused learning outcomes look like? How could Teacher 2 know when she had been successful in achieving these different types of outcomes (i.e., not content acquisition *per se*) rather than the researcher judging this?
- Why do these different outcomes matter, and to whom? What should the teacher be highlighting for further comment from the students' responses?
- Having got this far, what might the next steps look like? Where was all this leading the students?

Such strategic questions are often addressed tacitly rather than explicitly when teachers are on the more certain ground of traditional practice. Change of the type this teacher attempted took her right out to the risky edge of her own learning, to a place that it seems unlikely she would have ventured without the serendipitous support that came from being part of the school's student voice initiative.

It is clear with hindsight that Teacher 2 needed still more support—and ongoing support—to continue rethinking her personal understanding of the purposes for learning intended by sub-strands of the the NoS strand of NZC. This was a journey with promising *beginnings* but no more. A sketchy and incomplete vision of change does not provide a secure foundation for experimenting on your own. However, this comment raises the question of how well we, the researchers, articulated the reasons for change and what refocused outcomes might look and sound like. A further important consideration is the amount of time and face-to-face support needed to co-construct understanding that is sufficiently robust to be transferred and adapted by the teacher.

Teacher 1's reluctance to let go of a traditional emphasis on assessment success as *the* driving impetus for learning is also food for thought. Again, she knew that change could be positive and she was willing to engage in exploring what change might look and feel like. Again the students responded positively to the changes she did make. But this did not appear to affect her classroom decision making or ultimate judgement about whether she had been successful in her teaching. Would she be more willing to at least consider a broader range of outcomes for learning if the focus of high-stakes assessments (in this case NCEA) were redirected to signal that these are at least as important as building content knowledge?

An unpublished audit of achievement standards carried out at the start of the project suggested that any NoS links specified were likely to be under-developed and were often token links rather than demonstrably changing the assessment focus *per se*. Some science teachers do seem to realise this. When responding to the 2012 NZCER National Survey of Secondary Schools, mathematics and science teachers were over-represented in the 16 percent of teachers (n = 1,266) who disagreed that the realigned standards successfully capture the intent of *The New Zealand Curriculum* (Hipkins, 2013). A clear implication for policy is that assessment and curriculum do need to be well aligned, and understood as such by teachers. Clear modelling of assessable outcomes that reflect the intent of the NoS strand of NZC could provide Teacher 1 with the impetus to update the traditional content-focused curriculum she currently teaches. Teacher 2 would also benefit from being able to see different types of outcomes more clearly, to help guide her pedagogical thinking through the whole of a lesson sequence.

The final reflective comment comes from the researcher who worked hard to support both teachers. She noted that for the teachers the project must have seemed at times like "working on shifting sand". Both teachers were willing to change, but for different reasons neither could see

the whole picture of what that change might look like. This is an important consideration and a cautionary note for anyone who works with teachers to change their practice, or who develops resources to support such change.

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