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Introduction

This booklet specifically focuses on interactions between teachers and students. Research in this area typically focuses on talk and writing. Though we examined these modes in the InSiTE project, we also broadened our focus and examined other ways of interacting.

Interactions around the ideas in science and technology provide opportunities for teachers to assess and respond to student learning. We were interested in what helped and hindered these interactions, and the perspectives students and teachers held about interactions that support student learning. Hence, our focus in this booklet is on the joint contribution of teachers, students, tasks and the setting to interaction.

When we looked at interactions in the classroom, we saw that they were multimodal activities that incorporate the use of talk, written text, action and the visual mode to express and make meaning. Artefacts often provide scenarios and resources for interaction. Social and relational aspects of interaction also contribute to how authority in the classroom is distributed, as well as to the level of student agency. How authority is distributed and agency is achieved within and across interactions has implications for the construction of what it means to learn, know and do science and technology. It has implications for the opportunities students have to exercise agency and engage in assessment for learning. It needs to be pointed out that the examples included here are indicative only of the ways interaction played out in the InSiTE classrooms.

The booklet is divided into two sections. Each section explores some of the underlying ideas related to interactions in science and technology education. The sections are:

- Multimodal ways of learning: How writing, drawing and visual materials support talk in the science and technology classroom
- How artefacts provide scenarios and resources for interaction

Multimodal ways of learning

How writing, drawing and visual materials support talk in the science and technology classroom

Research often focuses on talk and writing, but teachers and students make use of drawing, gesture, modelling and visual material to help them communicate ideas to each other. That is, they use all the modes and media available to them. This section provides examples of some of these uses.

This section is divided into four subsections:

- Written records support talk and the development of ideas
- Enhancing talk with drawing
- Using visual materials to anchor and augment talk
- Augmenting talk with modelling, demonstrative action and dramatisation

Written records support talk and the development of ideas

Creating a written record allows students to review ideas and gather further meaning from them. Students are often asked to record their ideas in writing at the end and/or beginning of a task or lesson. This can be an obstacle to younger students if they have limited writing skills. In the InSiTE study, the early-years teachers provided support for this process by requiring the students to write a group response or by annotating a student's writing in discussion with the student. Older students were able to record their ideas much more independently, although teachers supported them by posting, in an accessible manner, a list of the terminology associated with the topic under study.

Brenda and her Year 4 class

The following excerpt from a Year 4 lesson is one example of how a written record of student talk supported independent student synthesis and analysis of ideas:

> During the first lesson in a science unit on force, Brenda introduced the notion of a force as something that caused motion. To introduce this she modelled moving a pencil, a table and a ruler using exaggerated movements. As she did these actions she questioned the students about what she was doing to cause movement. A student recorded all suggestions on the whiteboard. These suggestions included pushing, blowing, kicking, hitting and so on. At the end of this action-talk-writing sequence there were five lists of movement actions recorded side by side on the whiteboard. A student then called out, 'Miss G, they all have "push" in them.' Brenda picked up on this comment and asked the students to look across all the comments and consider to what extent the written actions involved pushing. The class concluded that most did.

Brenda was able to focus with her students on the science content and the skill of being able to write did not become an obstacle. >

In this example, the teacher was able to go beyond the constraint of "being able to write". Augmenting talk with the written record multiplied the meaning that the students were able to distil from the activity. This distillation allowed Brenda to draw the student ideas into the lesson to develop a definition.

Questions for you

- Do you have any similar experiences of the way a public record can allow students to synthesise across events?

What could you do?

- You could invite senior students to help in class and be "recorders" of ideas. This could be done as a group activity, for example, and the students could write on A3 posters. These could also be used for future reference and displayed in a public space.
- You could provide students with a tape recorder or a digital recorder to record their discussion.

Enhancing talk with drawing

The InSiTE teachers and students often used the visual mode in teacher–whole-class interaction, teacher–group and teacher–individual student interaction.

Gail and her Year 3 class

An example was a lesson in Gail's classroom where she used student drawings to develop student understandings of design requirements:

Drawings provided a forum for discussion and teacher feedback. >

> Gail, having modelled how to draw a side view and a top or bird's eye view, asked her Year 3 students to sketch the lunch box they planned to make to hold a 'healthy lunch'. By talking with them about their drawings, she was able to draw their attention to the need for a hinging mechanism, a fastener and the implications of some of their proposed measurements.

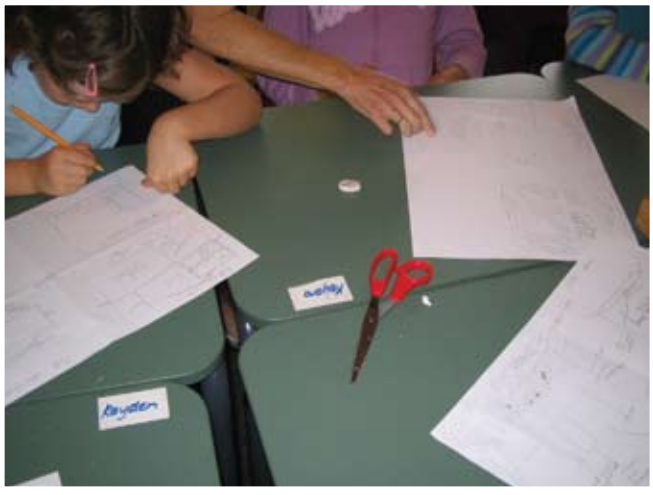
This example illustrates that drawings can anchor and augment talk to support the development of a shared understanding of the intent and potential limitations of a particular design. It also illustrates how student drawing can support teacher provision of meaningful (and useful) feedback leading to the expansion of student solution approaches. The need for a conversation to involve more than talk is evident in this example, which was just one of many occasions where the InSiTE teachers augmented talk by drawing themselves and/or asking their students to draw and explain ideas in both science and technology.

Questions for you

- Thinking about your own students, what do you think might be the benefit of asking them to draw before or while talking with them?

What could you do?

- You could get your students to draw their ideas, or take photos and ask them to talk about their drawings or photos. These can become a valued record for the student for self-reflection and can also be used as a teacher formative assessment tool.



Students drawing their designs

Using visual materials to anchor and augment talk

The InSiTE teachers made substantial use of pictures and images accessed from books, newspapers and the Internet, along with digital photographs they had taken themselves. They used images to:

- stimulate student curiosity
- marshal student interest
- co-ordinate talk
- inform talk.

Tayla and her Years 7–8 class

In this next example, Tayla combined student examination of the real thing (moulds on fruit from home) with student analysis of large magnified images of the same items:

> The students had already examined the mould on feijoas brought from home, pointing at and talking about what they could see. They had looked at the mould using a normal microscope but not been able to identify any specific features. Tayla then projected a 60x digital microscope image of the mould onto an interactive whiteboard and the spores became apparent. When Tayla increased the magnification to 200x there were exclamations of amazement from the students. They made comments such as: 'It's all spores', 'You can see the hyphae' and 'It's like a wet spider's web. Like caves.'
>
> Once the initial buzz had died down, Tayla drew student attention to a large wall chart that illustrated and labelled the parts of mould. She encouraged the students to link the shapes in the microscope image with those on the chart and to use the scientific names for the parts of the mould. The students could be heard doing this. Tayla went on to show the students a number of moulds. For each mould she prompted them to identify spores, hyphae and mycelium. Tayla concluded this sequence by stating that 'Even though they are different to our own eyes, they are actually the same.'

In this example, meaning was constituted through and constructed by the interaction of teacher and student talk with the enlarged images and the drawings and visual text on the wall chart. The public negotiation of meaning provided an equitable forum for student and teacher contributions and feedback.

< By using the large image, Tayla was able to work with the class as a whole to guide the development of individual student understanding of the specific parts of mould, rather than move around the class working sequentially with different groups.

Questions for you

- Thinking about your own experiences, what are the benefits of using large visual resources in whole-class settings? Is any particular type of visual more effective in supporting talk?

What could you do?

- You could use wall charts or stylised drawings that are in a shared public space.
- To help them work independently, you could encourage your students to use a permanent display as a reference point.
- If you already develop a wall display throughout a unit, you might like to think about how you could make more use of this as a teaching tool in class discussion.
- You could make deliberate use of actual objects and magnified versions of them, helping students to see the links between the two, particularly in the case of diagrammatic versions of objects where science conventions apply.

Augmenting talk with modelling, demonstrative action and dramatisation

Action as a mode for expressing, developing and evaluating meaning includes the use of gesture, the use of space, modelling, demonstrative action and dramatisation. The InSiTE teachers and students made use of all of these aspects. The teachers valued hands-on activities because they considered that students learnt from and enjoyed being actively involved in the learning process, and so they provided ample opportunities to use action as a mode. The teachers modelled and demonstrated skills, practices and the conduct of tasks. Teacher modelling of how to do tasks and acting out ideas was an important aspect of many of the lessons we observed. Teachers modelled:

- skills and procedures in technology
- how to conduct and report experiments in science
- how to record results
- how to complete worksheets.

At the same time they introduced related vocabulary and ideas. Their actions and talk provided models of how to act and speak scientifically or technologically. Modelling and demonstrations helped students gain a sense of the conduct of a task and the part they were to play.

The teachers also guided students to act out practices and ideas. This student acting out was undertaken to enhance the introduction of a new idea and to provide an alternative means for students to engage with and express ideas. Groups of students worked together to dramatise ideas, providing a stimulus to, and a forum for, talk, because students needed to explain and justify any suggestions for collective action.

Lois and her Years 1–3 class

For example, Lois introduced her Years 1–3 students to the notion of a batch production line as a mechanism for a group of people to work together to produce a healthy snack. She did this by dramatising the process. This was in the third lesson in a four-lesson technology unit on the development of a healthy snack:

> Teacher: We are going to have a production line. If we were making a sandwich, what would we do? Let's make a peanut butter sandwich. Come up May and Nicki.
>
> [May and Nicki move to the front of the class and stand side by side beside Lois.]
>
> Teacher: What is my job? [She pretends to pick up a slice of bread.] I am going to put on the butter. May, you will put on the peanut butter. Nicki, you will cut it. Could I put the peanut butter on?
>
> Class: No.
>
> Teacher: Could I cut it?
>
> Class: No.

Teacher: I don't do May's job and she doesn't do mine? Let's act it out.

[Lois pretends to butter the bread.]

Teacher: I'm buttering the bread.

[She hands the sandwich on to May. May pretends to put on peanut butter.]

Teacher: May is putting on the peanut butter.

[May hands the sandwich on to Nicki. Nicki pretends to cut the sandwich.]

Teacher: Nicki is cutting the sandwich. Everyone does their own job.

Teacher: In your groups you need to sit at your table. You need to work out what everyone's job is. So what is Joss's job? What is Olive's job? What will be Lance's job?

Lois's students took the job allocation seriously, with each undertaking only their assigned role in the actual production process the next day. The continuity of experiences—beginning with acting out a production line, followed by the students' independent group work using a production line to produce a healthy snack, followed by a whole-class recap on batch production and the use of production lines—helped the students build an understanding of the key features of a production line.

Questions for you

- In your view, what is the difference between describing and demonstrating a practice? Why might you choose to demonstrate? What would be the advantage of describing *and* demonstrating?

What could you do?

- Modelling of how to do certain tasks can be done by you or by students. This will help students gain a sense of how to do a task and what their role will be.
- The InSiTE teachers sometimes asked students to dramatise science ideas, such as creating a mixture dance and acting out what happens when materials are heated. Could you do this with your class? Could you also act out the discovery of an idea to help students understand how science ideas were developed?
- Have students act out a process. You could then discuss with them potential pitfalls and/or ways to improve the process before doing it for real.

How artefacts provide scenarios and resources for interaction

Teachers use objects and physical artefacts as a matter of course in their teaching. These provide both scenarios and resources for interaction through the way they anchor, augment and provide an alternative for talk.

For simplicity we distinguish between two kinds of artefacts—those from real life, such as fossils, tongs and kites, and those that are designed and made by teachers and students. This section is divided into three subsections:

- Augmenting talk with real artefacts
- Teacher-designed artefacts for interaction
- Student-produced artefacts

Augmenting talk with real artefacts

In science lessons, the InSiTE teachers made time for students to observe and handle sets of objects to establish a basis of common knowledge of items such as seeds, fossils and moulds. This was important because this analysis of objects could then be a shared experience. Teachers did not take for granted that all students already had these experiences. By providing shared experiences, teachers were surer that there was a resource for further learning.

Jane and her new-entrant class

The issue of what student prior knowledge they could reasonably assume was particularly problematic for the early years' teachers, because their students had very little shared school experience to call on:

> The InSiTE teachers used authentic, everyday items to stimulate student interest and as a focus for students thinking about and developing ideas and processes.

One student in Jane's new-entrant class did not know what a seed was, and many of her students indicated they had not had any experience with planting seeds to grow plants. Jane spent some whole-class time guiding the students in the examination of different types of seeds. The students visited the school gardens with the school gardener and talked about his plans for future planting.

Gail and her Years 4–5 class

Examining artefacts in technology required an appreciation of both the conceptual and physical aspects, as this helped students gain an understanding of what technologists refer to as *form and function*. Teacher guidance was important in helping students appreciate both aspects and their relationship. For example:

A class of Years 4–5 students undertook a teacher-guided examination of a set of tong-like artefacts prior to their producing a tong themselves. With the students in a semicircle, the teacher introduced a number of tong-like tools (Figure 1). She named each tool, demonstrated its action and function and then placed it in the circle. The

Figure 1. Class looking at examples of tongs

tools included fire tongs, salad tongs, a stapler, a nutcracker, an egg slice, scissors and a bulldog clip. One student offered her hairgrip as a tong that was similar to the bulldog clip. This indicated that she had synthesised the salient features of a tong. Her hairgrip was also placed in the circle.

< Teacher use of real artefacts in technology differed somewhat from their use of artefacts in science in that it tended to be more elaborated. In part this is because technology involves problem solving and innovating around an understanding of currently available technological outcomes.

Real artefacts in technology can:

- help students identify and build criteria for making things
- provide a model to support designing and making
- support students when they are drawing a design from different perspectives
- help sustain interest and engagement
- play a pivotal role in student understanding of criteria for the self-assessment of their outcome.

Real artefacts play a role in helping students to make explicit and extend their prior knowledge. They support the development of a shared or common knowledge.

Questions for you

- How do you use artefacts from real life in technology lessons? How does this differ from how you use them in science lessons?

What could you do?

- You could use real artefacts in science to probe for prior knowledge.
- You could have students examine a grouping of relevant artefacts in technology and develop a list of common characteristics to develop their understandings about the artefacts—what they look like, how they are made, their materials and how they work.
- You could use an ambiguous artefact to stimulate and focus discussion. For instance, we found including an egg among a group of artefacts to be sorted into solids and liquids really stimulated debate amongst children.

Teacher-designed artefacts for interaction

Artefacts designed and produced by teachers can stimulate student interest and questions, cue student prior knowledge and introduce and explore new ideas, processes and skills. Such artefacts can help to organise and guide the flow of activity and talk. Artefact form and function (physical and conceptual aspects) play a role in the success and challenge of the artefact for each of these purposes.

Brenda and her Years 3–4 class

Here is an example from a technology classroom:

As part of a technology unit on cheese modification, a teacher got her students to taste-test three commercial cheeses. Her intention was that this task would introduce students to how to conduct a taste test whilst simultaneously providing a shared experience. To introduce the taste-test process and the criteria students could use to analyse and rate the cheeses, the teacher prepared the "Characteristics of different cheeses" worksheet.

Teacher designed-artefacts > can anchor student interaction and help hold student attention on the key ideas.

Figure 2. The "Characteristics of different cheeses" worksheet

The teacher used the worksheet (Figure 2) as a reference for talk and gesture. It allowed her to model the process for the completion of the taste test in a way that was visible to all. The worksheet provided a persistent public representation of the key criteria she wanted her students to focus on and use.

Gail and her Years 4–5 class

Teachers sometimes provide students with sets of material resources to be manipulated as an adjunct to talk. In both the whole-class and small-group setting, such sets are an interactive tool that provides a dynamic visual representation of the group consensus thinking at any one time. The manipulation of such sets supports the involvement of a number of students. Students can be encouraged to articulate and justify their ideas because they need to explain their reasoning when they move an artefact.

Figure 3. Cards sorted into a continuum

For example, Gail asked her students to sort a set of cards that identified different materials (paper, wood, sandpaper and so on) along a continuum based on which would produce the most friction as a "road" for a toy racing car (Figure 3). This allowed the whole class to participate and removed the need to write.

Questions for you

- What do you think would be the benefit of your thinking about both the form and the function (physical and conceptual aspects) of the artefacts you design?

What could you do?

- You could consider how you might use the idea of a set of objects that can be manipulated as an alternative way of helping students think through and represent their ideas.
- You could assess the size and format of the worksheets you use in small-group work to make sure that all group members have easy access.
- You might want to use a wall space and put up information that you and the students can interact with and manipulate over the duration of the unit.
- You might want to use images or photos to create timelines or relational diagrams. This can overcome the obstacle of having to use writing, and they can be used as a focus for discussion and to tease out ideas.

Student-produced artefacts

Teacher tasks often require students to produce an artefact. Typically, teachers provide opportunities for students to present and discuss their artefacts with each other. These are times when student-produced artefacts provide opportunities for talk while providing students with a sense of authority and ownership of the ideas they are sharing.

Gail and her Years 4–5 class

In a technology unit on tongs, the teacher set the students a group task of designing a tong. The students drew a design of a tong which they labelled using the language of the criteria they had developed previously (flexibility, size in centimetres, wide mouth, strength and 'grippiness'). When the students stood up in groups of four to present their drawings to the whole class, they gestured, pointed and referred to their drawing to support their design explanations (Figure 4). They pointed and spoke about the specific features, describing how the tong would work and why, and what it would be made out of.

When the students in the audience asked questions, the presenters often referred to their drawing to answer them. >

Figure 4. A group presenting their designs to the class

Teachers spend considerable time collecting and preparing material resources to support their students' learning. The artefacts the teachers use provide scenarios and resources for interaction through the interplay of their material and conceptual aspects.

In this resource, teachers' real names are used in the "Teachers Talking to Teachers" stories. Otherwise, names are pseudonyms.

The InSiTE research was undertaken between 2005 and 2007 when the revised curriculum (Ministry of Education, 2007) was not finalised. Therefore the teachers involved in this research based their work on the previous science and technology curriculum documents (Ministry of Education, 1993, 1995). However, given the changes indicated in The New Zealand Curriculum *(Ministry of Education, 2007), we have made links to it where possible without distorting the integrity of the findings themselves.*

References

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Teachers and students communicate their ideas to each other as they interact in the classroom. Effective interactions are therefore important for developing student understandings. The InSiTE project explored the ways these interactions worked in science and technology units.

This booklet illustrates how talk, writing, drawing, action and visuals all worked together to support student learning, and how artefacts, such as worksheets or real objects, provided a focus and anchor for interactions.

This booklet outlines some findings related to teacher knowledge for primary teachers that were derived from a Teaching and Learning Research Initiative (TLRI) project, The Classroom InSiTE Project: Understanding Classroom Interactions to Enhance Teaching and Learning in Science and Technology in Years 1–8. The project involved working in classrooms over three years with Years 1–8 teachers when they taught science and technology to their students. The project aimed to identify, investigate and enhance ways of teaching science and technology.