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The representation construction approach detailed in Chapter 3 evolved from an ongoing collaboration between researchers and participating teachers. This chapter explores the teachers’ perspectives of the approach as it developed over the life of the Role of Representations in Learning Science (RILS) project. The teachers became strong advocates of the representation construction approach, and what follows are their accounts of what it offered their practice and to explore what it was about the approach that they came to value.

To provide insight into the teachers’ perspective, case studies are given of two secondary teachers whose participation in the RILS project extended over the life of the project. This chapter also raises the question of the potential of the representation construction approach to achieve wide scale acceptance, based on the experience of a teacher involved over a shorter period of time with the project.

THE RILS TEACHERS

Over the duration of the RILS project the researchers studied classroom sequences taught by 10 different teachers. The sequences were in a wide variety of topics that included Light, Astronomy, Forces, Motion, Cells and Genetics, Flight, Ionic and Molecular Structure, Living Things, Substance, Water, Energy and Ideas about Matter taught to students of various middle years levels (Years 5–10). Of this cohort of teachers the researchers worked particularly closely with five teachers in topic development, involving determination of the key concepts and skills that framed each topic and exploration of how the representation construction approach might be applied to teach such concepts and skills. Table 8.1 provides the dates, topics and Year level of students for these five teachers. It shows that there were two sets of teachers, Lyn/Sally and Lauren/Malcolm, who worked on the RILS project for four sequences each whilst Therese only became involved for one sequence. Although there was collaboration of the teachers with the researchers in topic development...
these teachers were ultimately responsible for the operation of the ideas in the classroom and increasingly became autonomous advocates of the representation construction approach.

Among the secondary school teachers Lyn and Sally were both experienced classroom practitioners whilst Therese was just in her third year of teaching. It is quite common for teachers in Australian secondary schools to teach general science to students at Year 7–10 level and specialize in teaching a specific science discipline in Years 11 and 12. Lyn and Sally were biology trained specialists whilst Therese was specialist trained in both Biology and Chemistry. Lyn and Sally taught at the one school and worked closely together in planning and implementing the topics that were taught, whilst Therese taught at another school.

Table 8.1. Topic sequences taught by the teachers in collaboration with the researchers

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Teachers</th>
<th>Year level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sept. 2007</td>
<td>Forces</td>
<td>Lyn/Sally</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Animals</td>
<td>Lauren/Malcolm</td>
<td>5/6</td>
</tr>
<tr>
<td>May 2008</td>
<td>Substance</td>
<td>Lyn/Sally</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Water</td>
<td>Lauren/Malcolm</td>
<td>5/6</td>
</tr>
<tr>
<td>Aug. 2008</td>
<td>Astronomy</td>
<td>Lyn/Sally</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Energy</td>
<td>Lauren/Malcolm</td>
<td>5/6</td>
</tr>
<tr>
<td>May 2009</td>
<td>Forces</td>
<td>Sally</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Animals</td>
<td>Lauren/Malcolm</td>
<td>5/6</td>
</tr>
<tr>
<td>Feb. 2010</td>
<td>Ideas about matter</td>
<td>Therese</td>
<td>7</td>
</tr>
</tbody>
</table>

The primary school teachers, Lauren and Malcolm, were both experienced classroom practitioners and taught at the same school. They each had responsibility for a single Year level class but often brought their classes together and team taught the combined class. They did this when teaching the science topics as part of the RILS project. Like Lyn and Sally these teachers worked closely together in planning and implementing the science topics.

SUPPORT FOR TEACHERS IN IMPLEMENTING A NEW PEDAGOGICAL APPROACH

The support provided to the RILS teachers provided professional learning experiences that impacted on their teaching practices and perspectives of teaching and learning science. The professional growth of a teacher that leads to a change of practice should be considered as a result of a complex process (Clarke & Hollingsworth, 2002). The literature points to several factors that may support a teacher’s professional growth in addition to indicating factors that might inhibit growth. One possible inhibiting factor to a teacher’s professional growth is the extent of the teacher’s professional knowledge.
A teacher’s professional knowledge determines the role they play in providing learning environments that result in successful learning outcomes for students in understanding science. The teacher’s professional knowledge needs to include content knowledge of the discipline of science and pedagogical content knowledge (PCK, Shulman, 1986). Shulman (1986) defined PCK as “the way of representing and formulating the subject that make it comprehensible to others... an understanding of what makes the learning of specific topics easy or difficult (p.9)”. Gess-Newsome (2001) makes the point that superficial content knowledge may restrict the ability of the teacher to teach in a creative and innovative manner, which encourages and makes use of students’ questions. Instead, teachers with a superficial content knowledge tend to limit the use of students’ questions in classroom discourse and the development of conceptual connections. To support teachers who lack content knowledge Cohen and Hill (2000) suggest that professional development should focus not only on content but also pedagogy. This view is supported by Brunsell and Marcks (2005) who state that professional development in science education should “focus on providing teachers with a coherent structure and methods of communicating that structure to students…. [and] continuing support to participants as they deepen their content understanding and change their teaching practices (p. 46)”. The representation construction teaching approach provided the teachers with a coherent structure and methods of communicating that structure to their students. This was particularly pertinent in those topics that were taught by the teachers who in the past had less confidence in teaching because of their perceived lack of content knowledge. The researchers provided continuing support to the teachers as they implemented this approach in all the topic sequences.

To enhance a teacher’s PCK Danaia and McKinnon (2008) suggest that they need to have some understanding of common alternative conceptions, including ways of dealing with those alternative conceptions their students bring to the classroom. Bakkas and Mikropoulos (2003) point out that the sometimes limited success of conventional teaching methods in overcoming students’ alternative conceptions may be due to a lack of appropriate teaching aids in the form of representations that can intervene dynamically in influencing the learning process.

Prior to the beginning of each topic the researchers collaborated with the teachers in identifying the key ideas and their representational forms that would guide the representational work to be implemented in the topic sequence (Principle 1 of the approach – see Chapter 3). Part of this topic development also included an exploration of the student conceptions literature, which was provided by the researchers. Common alternative conceptions were discussed and ways to deal with them came to be viewed as a representational issue. Out of these discussions activities to address common alternative conceptions, based on a representation construction approach, were generated and work-shopped by the researchers and the teachers. Discussion of key ideas and common alternative conceptions also led to the construction of diagnostic tests that were informed by the research
literature and were administered to the students as one of the first tasks in the topic sequences.

The collaboration between the researchers and teachers took several forms. In team workshops, the researchers would sometimes model representation construction activities to implement in the topic sequence, with the teachers taking on the role as student learners. These workshops engaged teachers in concrete tasks rather than abstract discussions of teaching. During the lesson sequences brief conversations between the researchers and teachers often occurred following the video-taping of lessons. Extended meetings also occurred during the topic sequences at times when the teachers were not teaching. During these times the development of students’ ideas, as evidenced by their responses to the representational challenges embedded in the representation construction approach, were often discussed. Such discussions informed future planning of the topic, sometimes involving ideas for activities, or offers of practical resource support such as digital microscopes. Following the topic sequences further meetings were held to reflect on the teaching and learning that had occurred and, in particular, the efficacy of the representation construction approach for improving student learning outcomes. Throughout the RILS project there was constant two-way communication between researchers and teachers in terms of sharing of ideas and discussing the progress of the lesson sequence.

The nature and duration of the support offered to the teachers over the period of the RILS project had a number of characteristics consistent with the literature on effective professional learning practices. This literature supports the view that effective professional learning should be directly aligned with student learning needs, is intensive, ongoing and connected to practice, and focuses on the specific teaching and learning of academic content (Gell-Newsome, 2001; Stiles et al., 2010; Wei et al., 2009). The RILS teachers adopted the representation-construction approach within topics they would normally be teaching. A focus on student learning needs was very much part of the teaching approach and professional learning support was ongoing for the duration of the RILS project. The teachers’ participation in the workshops that preceded the topic sequences provided them with a greater sense of efficacy for teaching the topics. This is consistent with the findings of Wei et al. (2009) who found higher levels of teacher efficacy where the professional learning experiences gave teachers the opportunity to undertake hands-on activities which enhanced their knowledge of the content to be taught and how it is to be taught.

To provide insight into the RILS teachers’ perspectives of the representation construction approach the next section provides cases of Lyn and Sally. The data sources drawn on for these cases included video of each lesson, student artefacts, students and teacher interviews, discussions with teachers at wider research team meetings, and field notes by the researcher who sat in on each lesson. The video data from each lesson came from two cameras, one which was directed at the teacher, and another on a group of students. Studiocode software was used to analyse the video data.
THE CASES OF LYN AND SALLY

As previously mentioned, Lyn and Sally were experienced teachers who taught at the same secondary school. These teachers decided on the selection of the topics for the RILS project and its timing in delivery. These decisions usually matched the teaching program followed by the teachers in previous years. As part of the RILS project Lyn and Sally taught three topics (see Table 1) to the same group of students. In the first topic the students were in Year 7 and around 12 years of age; the second and third topics were taught to the students a year later when they were in Year 8. The duration of each topic was 12–14 lessons; most lessons were 45 minutes in duration and every third lesson was 90 minutes duration.

Planning Stage of Topic Sequence

Being biology-trained specialists each of the RILS topics had content that was outside the teachers’ discipline expertise so the challenge for them was a combination of content knowledge and PCK. The initial approach to planning the topic sequence was similar for each of the three topics and represents Principle 1a of the representation construction approach whereby teachers need to clearly identify big ideas, key concepts and their representations, at the planning stage of a topic in order to guide refinement of representational work. The teaching sequences were therefore informed by a clear conceptual focus. The initial lessons in each sequence focused on exploration of students’ prior views, generation of students’ representations, and introduction of the scientific conventions that underpinned each topic. Each teacher followed a similar sequence of activities, but in fact the video record showed that each was different in the way they introduced ideas, led discussions, and achieved some form of closure.

In taking a conceptual focus to topic planning the teachers moved away from their previous practices. This was clearly evident in the forces topic which was the first of the three topics taught (Table 1). In previous years the focus was in covering the curriculum content contained in the students’ textbook (Lofts & Evergreen, 2006), and the title of the topic, Forces in Action, matched the chapter title in the textbook. The textbook chapter, and subsequent teaching, moved quickly through a range of forces, for example buoyancy and surface tension, electrostatic forces, magnetic forces, electromagnetic forces, gravity and air resistance.

During the planning stage the teachers gained confidence in moving in a direction away from the textbook that framed their pedagogical approach to more of a conceptual focus. In reflecting on this change following the completion of the topic Lyn commented:

Before we crammed it all in and didn’t know what to cut out...we were so pleased to actually pause, particularly in that forces unit, which was so superficial and done so badly according to the textbook that we were using.
We were so pleased to go into depth. And it was so lovely to be able to develop ideas with the kids.

The conceptual focus resulted in less curriculum coverage than in previous years with its textbook focus, thus illustrating a current science education reform push for the distillation of science content coverage to develop deep conceptual knowledge in students.

Prior to the Astronomy topic both teachers expressed a reluctance to teach it based on their perceived lack of content knowledge. For Lyn, Astronomy “has been difficult to understand and teach” and this meant that she taught this topic in the past with “more delivery of facts rather than exploration of understanding”. For Sally, the topic of Astronomy was one “I had never done it in school myself and I have never learnt the topic myself, only read it through books and watching movies and so on but it was the fact that it was the topic that was endless”. Her main concern was that “the kids could ask you lots and lots of questions and I was aware that half the time I may not have the answers straight away and would need to come back to them later. I mean that was the fear factor”.

In taking a conceptual focus at the planning stage the teachers developed the view that rather than dealing with what Sally initially referred to as an endless topic, the topic of astronomy should focus clearly on a set of interconnected key ideas about astronomical phenomena that arise from simple dynamic systems such as the Earth, Moon and Sun connected by gravity. The team work-shopped activities that had a representational focus and discussed the implications of these for student learning bearing in mind possible alternative conceptions the students might have. The workshop activities resulted in a greater level of confidence by the teachers in tackling the teaching of astronomy. This was evident in the following exchange with Sally.

Researcher: I remember you saying something after our first workshop that you felt a little bit more comfortable about teaching [Astronomy] so what was in the workshop that gave you that confidence?

Sally: I think the role-plays, how to actually go about teaching the topic and using ourselves, using the models, and understanding of relative distances… I think that really was a wow factor and I put myself in the shoes of the kids and I thought, yes that would be something I could feel comfortable in teaching.

The representational focus to discussion and activities in the workshop placed demands not only on the teachers’ pedagogical content knowledge but also their content knowledge. The teachers found that both types of knowledge were enhanced by this process.

**Impact of Students’ Prior Knowledge on the Teachers’ Practice**

The students’ conceptions research formed part of the discussions that informed the planning of the topic sequences as well as the development of diagnostic tests. These
were administered to the students in each of the topics. For the topics of substances and astronomy the tests were administered at the beginning of the sequences and covered most of the ideas to be taught whereas the test for forces was focused only on the students’ ideas relating to gravity and was administered during the topic sequence.

For the substances topic the teachers had planned a topic sequence that extended on a previous year’s topic on changes of state and particle model with the introduction of the concepts of atom, molecule, element, compound, mixture and pure substance. The diagnostic test that was developed explored the students’ understanding of the previous year’s topic which involved the particle model. When the test was administered the teachers were somewhat surprised at the prevalence of alternative conceptions elicited by the students. This prompted them to rethink the way they were teaching particle ideas about matter.

The substances diagnostic test responses indicated that whilst the majority of students understood the term atom and molecules they exhibited several alternative conceptions that indicated a lack of understanding of the use of the particle model to explain macroscopic properties of matter. The teachers realized that they had been teaching the particle theory as a body of knowledge itself and only loosely using it to explain macroscopic behaviour of matter. They now thought that the teaching approach needed to have constant movement between macroscopic behaviour of substance and particle ideas through various forms of representation that explain the behaviour. There was also a view that there needed to be an emphasis on evaluating the adequacy of a particular representation to explain a particular behavior. These views are reflected in the following comment by Lyn:

So what we would have done before is teach the particle theory and then incidentally relate it to real life. But through teaching the Year 8s we realized that the model has to sit within everyday experiences. But you know we’re not teaching the particle model as in, this is the model and see how it relates to real life. It’s more, this is real life and we have a model and does it actually explain real life, and does it explain this and that? And particularly, one of the areas I focus on, is how good is the representation?

Lyn’s comment not only expresses a change in pedagogical practice it also points to an epistemological change whereby, according to Lyn, “The model has to sit within everyday experiences” and is not separate to how one thinks about explanations of the properties of substances. In thinking about the implications from the substances pre-test results the teachers shifted to a greater attention to students’ prior views.

The greater conceptual focus in each topic resulted in a greater perceived awareness of the students’ developing understandings of the key ideas. This is illustrated in the following comment by Sally:

I found it a real valuable experience and its interesting how we pick up all these misconceptions and it has been a challenging experience as well.
Sally saw direct benefit in gaining knowledge of the research literature in terms of students’ alternative conceptions at the planning stage in suggesting:

I find it deeply rewarding that here is a list of things that kids often get wrong, and I have a look at them and actually have a chance to stop the kids from developing really deep misconceptions, and I love that.

The teachers saw benefit in the knowledge gained from the diagnostic tests in terms of targeting the teaching in resolving misconceptions that arose and for the students to be made aware of their own thinking as an important part of the teaching sequence. This view is reflected in the following comment by Lyn:

Because we have more understanding of the misconceptions we can teach accordingly and we can single out misconceptions...we can tackle them straight away... if you are aware of what the misconceptions could be, you are explicitly telling the students that you know some people think this is so, it has a huge impact because the kids will not then go along those lines...The pre-test was used as a basis to begin discussions, it gave kids a good reference point.

Impact of Representation Construction Approach on the Teachers’ Classroom Practice

Both teachers were strongly of the opinion that the representation construction approach had significantly impacted on their classroom practice. The two teachers reported there was a significant pedagogical change in the manner in which ideas were introduced compared to their previous practice. At each stage of the topic sequences key ideas were approached through the canonical representational forms and student generated representations in response to the representational challenges. According to the teachers, the explicit negotiation of and discussion of representations of force, substance and astronomical phenomena led to a richer range of classroom discussion and opened up lines of inquiry that were closed in earlier versions of the topics. The requirement on students to generate and coordinate representations led to refinement of ideas in a shared classroom discussion.

In the forces topic there was explicit discussion of representations such as those associated with explaining the action of forces in everyday events. The development of the scientific convention of straight arrows representing forces was embedded in an authentic need to know and involved discussions on the partial nature of this convention in explaining forces. Sally stated that “when we taught forces previously you just barrel in, you start using arrows straight away, they just become incidental, so we never took the time to introduce the arrow or the significance of it... as representing force at all previously”. The students found that other visual representational modes such as drawings with annotations and curved arrows to indicate motion can enhance the explanation of an everyday action like screwing the top off a bottle of drink.
In the substances topic there was constant movement between macroscopic behaviour of substance and particle ideas through various forms of representation that explain the behaviour. Different particle representations, either generated by the teacher or the students, were discussed in terms of their adequacy in explaining properties of matter. Apart from the iconic pictorial representations of particles as spheres other forms, such as a picture of students on a bus, popcorn being made or a section of a jigsaw puzzle were discussed in terms of their particular features to explain macroscopic behaviour of matter in addition to those features that did not explain the behaviour. In other activities the students were challenged to generate their own representations, whether by role-play or in diagrammatic form to explain a variety of specific macroscopic behaviours of matter. For example, that candle wax goes ‘gooey’ when the candle is lit or that an elastic band can stretch without breaking.

In the astronomy topic there was an emphasis on coordinating different representational forms of the same astronomical phenomenon. For example, there was movement between the representational forms associated with perspectives of an observer from Earth, such as the photographic image of a solar eclipse, and representational forms associated with perspectives of an observer in space, such as role-playing the relative positions of Earth, Moon and Sun for a solar eclipse. The affordances and constraints of the representations formed part of the classroom discussions. For example, there was explicit discussion of the globe as a representation of Earth in space in terms of the affordances it has for representing certain features of Earth in addition to discussions as to the limitations of the globe in terms of not representing certain features of Earth. The students came to recognize representations as being intrinsically partial, such that a full account of an astronomical phenomenon required coordination of multiple representations.

A key feature of the representation construction approach is the generation and negotiation of student constructed representations in response to challenges and the canonical representational forms introduced by the teachers. This feature raised an issue for the teachers in terms of increased time allocation within a classroom lesson for negotiation and discussion of representations. Sally commented that she spent more time “when this approach is used because there is much more student debate and involvement as they challenge their own ideas and those of their peers”. This resulted in less curriculum content coverage when compared to the teaching of the same topics in previous years. However, the teachers were content to sacrifice coverage for the greater depth offered by this approach which paid dividends in terms of student learning. This view was expressed by Sally thus:

We cover less content but we are tackling the big ideas much more effectively. I think that we make up for this slower pace when we extend concepts later in the syllabus. I expect this is due the deeper level of student understanding that is so much higher - because representations are used and introduced in this way.
This comment also points to the importance of establishing in students a deep understanding of key ideas that can form a strong base for future learning given the interconnectedness of ideas linked by representations.

Lyn found the time factor associated with negotiation and discussion of representations needs to be considered in lesson planning to allow “sufficient time to for students to formulate and consolidate their ideas …. one needs to be prepared for the series of questions that students will generate and expand on the topic”. Thus, a certain amount of flexibility is required by the teacher, associated with the greater agency given to the students in determining the direction and flow of the lesson. For the teachers this meant a change in their lesson planning practices where they were now preparing for possible changes in direction resulting from classroom interactions rather than following a fixed planning schedule which was their previous practice. Sally described it thus:

…you plan your lesson with a lot of possibilities. You think about okay what if the students ask me this question, what kind of activities can I have and I’m a little bit more prepared …now way back, if I did this last year, I would’ve prepared a whole 5-week lesson and I’d be teaching it lesson, by lesson, by lesson. So that’s the progression.

The teachers considered that the amount of discussion was more than experienced in previously taught science topics. Sally described how “there were more discussions, we did a lot more application how does it work in the real world kids were given time to actually think”. Lyn commented that is was “most rewarding thing taking stuff in their everyday experiences into the science room…that type of conversation would not have occurred before, and that’s the richness where you get the kids having science debates and conversations, rather than delivery of fact; it’s a higher order level of thinking and that was really fantastic”.

The teachers reported that they now paid more attention to discussing with the students the form and function of representations at those times when they were introduced by the teacher or naturally arose from the classroom interactions. For example, in the forces topic taught by Sally, a representational challenge to categorise action words to manipulate plasticene in tabular form in terms of ‘Push’ or ‘Pull’. Given there were some terms declared both a push and pull some students suggested a better representational form to a table might be a Venn diagram. This led to a discussion by Sally as to the function and form of Venn diagrams and instances where such a representational form might be suitably used. In reflecting on the need to discuss with the students the function and form of representations Lyn stated that

… we found that we had to teach the students the skills, and understanding how the representations work and what they meant. And once they had an understanding about what they were about, … they were thinking about what they were drawing, rather than drawing a diagram for the sake of drawing a diagram, to show what was on their mind… the kids were going further into it
and thinking of different ways [of representing]. So I think going further into it and teaching them why we choose certain representations, gets them in deeper.

From an epistemological perspective the teachers came to terms with the culturally produced nature of representations in the topics of force, substance and astronomy and their flexibility and power as tools for analysis and communication, as opposed to their previous assumption that this was given knowledge to be learnt as an end point. These realisations became empowering as they learnt to use representational challenges to drive classroom discussions and to achieve greater understandings themselves to interpret force and motion situations, apply particle ideas to explain properties of substances and interpret astronomical behaviour in terms of the interplay between simple dynamic systems of celestial objects. The power of the representational challenges was seen by Lyn as “...what you’re seeing with representation is that you’re seeing what’s in their brain, not what they’re regurgitating”. For Sally:

It’s good to give them a representation, but it’s more powerful when they re-represent it...it helps in their reasoning... it’s a very powerful way of showing understanding and getting the kids to think. And the other thing too, is it allows kids to be creative in showing their understanding with different representations. And we can all see different ways of doing it.

Over the three topics the teachers enhanced their content knowledge and pedagogical content knowledge, which was driven by undertaking the representation construction approach. The following quotes gives insight into the manner in which the teachers now perceived the role of representations in understanding science:

Lyn: Sometimes the representation will help us to get to that knowledge. So it is a continuous feed-back; as Sally said, if we try to understand the concepts we have to go to various types of representations...Representations help us get the knowledge, we use the knowledge to help to build our representations.

Researcher: So is it two-way?

Lyn: A circle. The representations helped our knowledge and our knowledge helped our representations and the more representations helped our knowledge and the more knowledge helped our representations. So it was more a continuous feedback working.

ISSUES RELATED TO A WIDER ACCEPTANCE OF A REPRESENTATION CONSTRUCTION TEACHING APPROACH

The case of Lyn and Sally highlights the efficacy of a representation construction teaching approach in terms of increased student engagement and improved learning outcomes. However, the approach does places epistemological and pedagogical
demands on the teacher. The challenges for Lyn and Sally were in terms of moving away from delivery of content that is conceived of as resolved knowledge structures, to pedagogical practices based on a discursive, more active view of knowledge and learning. In terms of the dissemination of the representation construction approach more widely the issue of the magnitude of the teacher learning task needs to be explored. If the representation construction approach is to gain wide acceptance we need to identify the type and duration of support needing to be given to teachers being inducted into the approach, for them to make the types of shifts experienced by Lyn and Sally.

The collaborative and ongoing support given to Lyn and Sally over the period of the RILS project is not viable as the basis for widespread implementation of the representation construction approach. Such professional development is simply too time intensive to be practicable at system level. The question then arises as to ‘what core skills and knowledge do teachers need to be supported to develop in being inducted into the approach, under conditions of restricted time and support implied by large scale professional development?’ The RILS project involved the participation of one or two teachers in single topics only, rather than support over multiple topics over two years. Therese is a teacher who was supported over one unit only, to develop the representation construction approach. Her case is offered as an example to explore whether restricted support compared to that offered Lyn and Sally might still be effective in supporting teachers to implement the approach.

The Case of Therese

Therese’s involvement in the RILS project was only in respect of teaching one topic, Ideas about Matter, to a class of Year 7 students. In contrast to Lyn and Sally, Therese was not an experienced teacher being in only her third year of teaching. However, Therese did have expertise from the perspective of content knowledge of the ideas about matter topic as she was a Biology and Chemistry specialist teacher. Therese’s involvement in the RILS project came at the end of the project (see Table 1) and by this time the research team had greater insight and confidence with the representation construction approach which helped brief Therese and offer examples. The research team collaborated with Therese from the development stage of the topic ensuring a conceptual focus was undertaken.

The epistemological and pedagogical demands on the teacher in adopting a representation construction approach to teaching ideas about matter were not seen as significant for Therese. For example, in respect of the function played by the particle model Therese was asked, “what do you see as the main purposes of introducing the particle model to Year 7?”

I see that the main purpose of introducing the particle model at Year 7 is that it gives the students the foundation of the true essence of Science. We aren’t able to see everything in the world around us so we do experiments
after experiments to try and make sense of it. The particle model enables the students to come up with their own idea of what substances are made up of and how they explain the behaviour of different states.

From a pedagogical perspective Therese was not surprised by the alternative conceptions evident in her students’ diagnostic test responses. She felt that “pre-test results for any Year 7 class should be quite similar. Therefore, there was nothing surprising for me for my classes”. According to Therese this perspective from the students’ conceptions literature was gained from “my [science teaching] degree where most of my assignments dealt with alternative conceptions with any topic.”

The topic sequence adopted by Therese was described in detail in Chapter 7. It draws on the principles described in Chapter 3. The initial lessons involved the students exploring properties of different substances, for example, comparing the properties of a rubber band with those of a stick of chalk. Particle ideas were then introduced on the basis of a need to explain a specific property of a substance. For example, after the students had been informed that scientists, whilst being unable to see inside matter, imagine it to be composed of particles, the students were set the representational challenge to draw the state of the particles to explain the property of a piece of paper’s ability to hold its shape. After students undertook this task three students were chosen to share their representation with the rest of the class (Figure 7.7 shows the students’ representations). Each representation was evaluated by the class as to whether it served its purpose.

The sequence continued with students challenged to construct particle representations that would account for a range of macroscopic properties such as chewing gum being able to be stretched without breaking. The student generated representations then formed the basis of class discussions focused on evaluating their success in making sense of the phenomenon. Representational conventions were negotiated and agreed upon by class consensus. For example, the class agreed on a multiple bracket convention to represent particles of a sample of a substance in a solid state; curved arrows to represent particles of a sample of a substance in a liquid state; and straight arrows to represent particles of a sample of a substance in a gas state (see Figure 8.1).

In reflecting on changes to her practice with the representation construction approach Therese felt “there was more class discussion in this teaching sequence as there were a lot of open ended questions set out to the students.... They all felt a part of the group if they got to share what they thought”. Therese cited more use of representations when she commented that “we normally just gave them the textbook representations. Now there is more getting them thinking them up themselves”. Therese felt that the students “get engaged more, it’s like a puzzle because they have to come up with a specific explanation like how can you explain why a piece of paper holds its shape”.

Just like Lyn and Sally, Therese found that taking a conceptual focus to planning the topic meant less curriculum content coverage. However, the interconnectedness
of ideas meant Therese introduced particle ideas about temperature earlier on in the sequence and had students thinking about bonding of particles when this wasn’t the case in previous iterations of this topic.

As for Sally and Lyn, less content coverage resulted from the representational focus. This is not surprising given that they spent class-time in getting students to generate and negotiate their own and canonical representations, which is something Therese, Sally or Lyn had not undertaken in the past. Therese stated that “I noticed this year that we were able to choose a couple of concepts that blended together well and used the time available to really connect with the students”. In justifying the introduction of particle ideas associated with temperature and bonding Therese stated that:

Temperature related to states of matter and is critical to the particle model as energy of particles is related to temperature. In the past we never really did bonding but we had the students thinking about bonding in this topic…because the students needed bonding to explain the properties of matter that were given as challenges, it explains how a rubber band can stretch.

Finally, Therese saw great benefit in getting students to generate representations as it provided an environment “to open up different ideas” and, from a formative assessment perspective, “this gave insight into their thinking and how they interpreted my teaching so this gave constant feedback on their understandings”. It was clearly evident that Therese embraced the representation construction approach in her teaching of a single RILS topic and her perceptions of the approach were similar, pedagogically and epistemologically, to those of Lyn and Sally.

Therese’s case provides some evidence that, with the more focused support enabled by the researchers’ growing experience of the approach and with a teacher sympathetic to the ideas, the representation construction approach can be successfully
supported over one unit of work. In Chapter 11 we will describe the outcomes of a professional learning initiative that explored the possibility of supporting teachers implement the approach through carefully planned workshops.

CONCLUSION

A key implication of the RILS study is the need to shift practice in teaching science from its current focus on the delivery of content that is conceived of as resolved knowledge structures, to the pedagogical practices of this representation approach based on a discursive, more active view of knowledge and learning. We argue that these classroom practices bear many resemblances to the epistemic practices of science itself. The shift will require changes in conceptions of the role of the teacher in the science classroom, and changes in how knowledge and learning are thought of in science. To make this change, teachers need to:

• understand the role of representation in learning science, implying both a pedagogical and an epistemological shift;
• develop understandings of the key representational resources underpinning a science topic;
• develop the skills to provide a representation rich environment and opportunities for students to negotiate, integrate, refine and translate across representations;
• make explicit to students the role of representation in learning science; and
• conceptualize learning in science in terms of students’ induction into the representational conventions and practices of science and their capacity to coordinate these.

The RILS teachers with whom the researchers worked closely exhibited in their teaching practice the dot point items listed above. These are the perspectives and capabilities needed by teachers learning to implement the approach. An issue for more widespread adoption of the approach concerns how teachers might be effectively but realistically supported to develop these capabilities. Given current concerns about the engagement of students in meaningful science learning, and the relatively limited success of pedagogical approaches based on cognitive views of learning, we would argue that this is an agenda that needs to be vigorously pursued both in research and policy.