Empowering teachers through a professional learning program focused on a representation intensive pedagogical approach

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Abstract

A representation-intensive pedagogical approach challenges students to generate and negotiate the representations (text, graphs, models, diagrams) that constitute the discursive practices of science, rather than focusing on the text-based, definitional versions of concepts. It thus represents a more active view of knowledge than traditional structural approaches. Previous research conducted on a small scale with a few topics and teachers, successfully demonstrated enhanced outcomes for students, in terms of sustained engagement with ideas, and quality learning, and for teachers enhanced pedagogical knowledge, and epistemological understanding. This paper explores the efficacy of embedding a representations-intensive pedagogical approach into a state-wide professional learning program that was delivered to secondary science teachers in Victoria, Australian, in 2010/2011. The professional learning program involved participating teachers undertaking two successive days of professional development, then completing a small classroom-based project in their schools before returning for the third day of professional development. The program was supported by an online drupal website. In determining the impact of the professional learning program on the teachers’ practice data was collected in the form of program participant surveys, presentations of the teachers’ classroom-based projects, focus group interviews and phone interviews.

Introduction

The widespread uptake of good ideas in curriculum, assessment and/or pedagogy generated from small-scale research projects can take a considerable length of time. For example, the extensive bibliography by Duit (2002) have many articles over several decades calling for more student-centered teaching and learning approaches that deliver improved learning outcomes for students and yet traditional teaching practices are common today (XXXX). The uptake of good ideas becomes more problematic if the ideas are more than ‘tips and tricks’ that teachers can incorporate into their existing practice but require substantive changes. Teachers are explicitly exposed to new ideas related to science teaching through science teacher journals, conferences and professional learning programs. Teachers have ready access to a wealth of new ideas via the internet but unless they know what to look for, and see a need for doing so, the information invariably remains hidden.

Professional learning programs focusing on the same content and delivered to large numbers of teachers might be seen as the best avenue for the initial exposure of good ideas leading to widespread uptake of these ideas. However, there are significant issues related to the delivery of such programs. At a system level, like the Victorian Department of Education and Early Childhood Development (DEECD) which manages all government schools in Victoria, funding for widespread professional learning programs generally comes from the system through decisions made by their managers. The system managers would seem to be the gatekeepers to wide-scale professional learning programs in their system and so from a perspective of the science education researcher with good ideas the issue then becomes ways to convince system managers of the veracity of the good ideas. This might prove problematic if evidence of good practice leading to enhanced learning outcomes for students is limited to small cohorts of students. Given that teachers report that much of the professional development available to them is not useful for them (Wei et al, 2009) it therefore becomes important to consider the structure and delivery of professional learning programs.

This paper describes how a representation-intensive pedagogical approach generated from a recently completed Australian Research Council (ARC) funded research project conducted on a small scale with a few topics and teachers came to be embedded in a state-wide DEECD funded professional learning professional
Empowering teachers through a professional learning program focused on a representation intensive approach learning program delivered to 181 teachers across Victoria, Australia. The research project was completed in 2009 and the professional learning program began in 2010.

The professional learning program called The Switched On Secondary Science Professional Learning (abbreviated as SOSSPL) introduced teachers to curriculum resources that encapsulate a representational focus to the teaching and learning of science embedded in an inquiry context (Hubber, 2009; Tytler & Hubber, 2010). It consists of three days professional learning. Days 1 and 2 are undertaken consecutively, with Day 3 following a break of several weeks. The aim of this paper is to report on the effectiveness of the representational intensive pedagogical approach to building teacher capacity to improve student learning outcomes in secondary science.

**Rationale for the study**

The rationale for the study is in the need to rejuvenate science teaching, so learning science is more enjoyable and popular. International research over the last twenty years has shown that students struggle to learn key science concepts in the middle years of schooling (Years 5 to 10) and this spurred an active conceptual change research literature across the two decades prior to 2000 (Duit & Treagust, 1998; Tytler, 2007). More recently, there is an emerging literature indicating the value of a representational focus for this learning that builds on this earlier conceptual change research, and it is this perspective that informs the Switched On Secondary Science Professional Learning (SOSSPL) program, which is to build teacher capacity to improve student learning outcomes in secondary science (Prain & Tytler, 2010). This representational focus draws on current understandings of science discourse as a mix of verbal, graphic and mathematical modes to represent the same and different science concepts and processes. There is a growing acceptance that understanding these modes, recognizing how they are used to construct scientific explanations, and negotiating the meaning of different representations are crucial to learning in science. There is also growing interest in the classroom discourse that leads to effective learning and reasoning in science. This SOSSPL program is designed to support teachers to plan and implement classroom sequences that focus on student construction and interpretation of different representations of science concepts and processes that are described by the Australian Science Victorian Essential Learning Standards (VELS) and the online teaching resources called the Science Continuum P-10.

Current science teaching practices incorporate the use of both authorised or justified representations as well as student-generated multiple and multi-modal representations for some topics (such as the use of 3D models, diagrams, verbal accounts, role-play, and CD-Rom illustrations for teaching topics like the solar system). At the same time, there is a growing recognition of the need for students to learn how to interpret, integrate, and reproduce multi-modal representations within and across topics if they are to develop understanding of a science topic, as part of a broader science literacy. The pedagogies involving representational challenge and negotiation that sit at the core of this approach must sit within discursive practices within the classroom that allow variation in the teacher and student voice as ideas are introduced and negotiated. Socio-cultural research that focuses on appropriate negotiation of teachers’ and students’ ideas in classroom talk (e.g. Alexander, 2008; Mercer et al., 2004) provides a pedagogical setting for exploring representations. This includes the communicative approach of Mortimer and Scott (2003) in which these authors trace the use of ‘dialogic’ (student voice, many ideas) and ‘authoritative’ (teacher voice, focused idea) talk and ‘interactive’ and ‘non-interactive’ talk to show how student ideas can productively interact with the canonical forms of science. Thus, a combination of a representational, and a discourse focus, has the capacity to offer a powerful professional learning combination for science teachers.

**Research Questions:**

1. What aspects of the state wide professional learning program are conducive to teacher learning?
2. What aspects of a representational intensive pedagogy make it effective for rejuvenating science teaching?
3. How can teachers apply a representational teaching approach to their teaching in their classrooms?
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Description of the professional learning program

The SOSSPL learning program introduced teachers to the idea of a representation, and the value in generating personal representations, the negotiation and interpretation of representations. The teachers were introduced to the concept of a scientific concept consisting of a set of interlinked representations and practices dispersed across multiple modes (diagrams/models, graphs and mathematical symbols, kinaesthetic experiences / gestures. During the SOSSPL program, teachers had to make representations, negotiate ideas with their peers and undertake hands-on activities. Issues related to how students learn science were discussed, including constructivist learning perspectives and the significance of students’ prior knowledge in learning something new. The role of representations in students learning was explored by examining the use of multiple representational resources to assemble the network of meanings across various representations. The key ideas underpinning the professional learning was recognising the need to:

- coordinate and reason with multi-modal representations of scientific concepts;
- explore students’ prior views.
- provide representational challenges
- encourage students to use of multiple representations to express their understanding of science

Teachers explored strategies such as the use of real-world applications, linking everyday language and scientific language, the use of analogy, metaphor and models, and the use of multiple modes of representation generated by the teacher and students. A wiki was constructed to provide portals for online resources and participant discussion spaces. An outline of the program for the professional learning program is shown in Table 1

<table>
<thead>
<tr>
<th>Day</th>
<th>Module morning</th>
<th>Module afternoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Understanding science</td>
<td>Pedagogical approaches to teaching science</td>
</tr>
<tr>
<td></td>
<td>What is it to know and understand a science concept?</td>
<td>Elicitation techniques; Learning about Forces</td>
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<tr>
<td></td>
<td>The role of representation in teaching and learning science, How students learn science</td>
<td>The e-instructional model &amp; teaching science</td>
</tr>
<tr>
<td></td>
<td>Students inquiring in contemporary science / society contexts</td>
<td>Learning abstract concepts: Ideas about Matter</td>
</tr>
<tr>
<td>2</td>
<td>Inquiry in the science classroom</td>
<td>Assessing understanding in science</td>
</tr>
<tr>
<td></td>
<td>The role of practical work in science classrooms</td>
<td>The purposes of assessment; Some assessment issues</td>
</tr>
<tr>
<td></td>
<td>Scientific inquiry and the nature of science</td>
<td>Planning a classroom-based project</td>
</tr>
<tr>
<td></td>
<td>Students inquiring in contemporary science / society contexts</td>
<td>The classroom-based project: expectations and obligations</td>
</tr>
<tr>
<td>3</td>
<td>Presentations of classroom-based projects</td>
<td>Resources for a contemporary science classroom</td>
</tr>
<tr>
<td></td>
<td>Teachers reflecting on their own understanding</td>
<td>Characteristics of the contemporary science classroom;</td>
</tr>
<tr>
<td></td>
<td>Showcasing the classroom based projects and reflecting on their own learning;</td>
<td>Resources for teaching in a contemporary science classroom</td>
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Implementation of classroom-based project (2-4 weeks)

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</table>

Research Design

A mixed mode methodology was used to measure the impact of the SOSSPL program on the participating teachers’ capacity to improve student learning outcomes during and following the professional learning program. The data sources included:

- Surveys
  - A pre-SOSSPL program survey to elicit participants” personal pedagogical approaches
  - A survey about the relevance and innovation of the program at the end of each day.
- Interviews
  - Teacher semi-structured focus-group at the end of 3 Day
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- Phone interviews with selected teachers 3-6 months after the program
- Wiki website with discussion data, project planning and project reports submitted by teachers.
- Presentation of classroom-based project and examples of student’s work

The sample size of 118 teachers in a range of teaching settings provided a good variety of quantitative and qualitative data. Case studies of individual teachers are provided as examples of how the representational pedagogy is applied in diverse situations. The survey data provides an overview of teacher’s perceptions of their learning and the usefulness of the program to their professional understanding. The presentations provide insight into teacher application of the representational approach to their own teaching contexts.

Results and Analyses and Findings

Each of the nine regions of Victoria held a SOSSPL programs for teachers from government schools. In total, 181 teachers participated in the programs that were rolled out over six months. There was a mix of teaching experience within the cohort of teachers who participated in the SOSSPL programs, ranging from 29% with less than 3 years teaching experience, 24% with between 3-5 years teaching experience and 15% with more than 20 years experience. The most common teaching area among the teachers was biology with 53% and the least common physics and environmental science – each with 15%.

In response to the question, “What do you hope to gain from undertaking the SOSSPL program?”, 79% of the teachers (141 teachers completed the survey) gave a response and the main issues raised by them were: New resources/teaching ideas; Ways to engage students; Improve one’s teaching practice; and Collaborate and share with other teachers.

The representational approach to teaching aligns well with these objectives. The representational focus was new to all the teachers and they reflected that it was motivating and that it provided them with a new approach to teaching science. The survey (Day1) results showed that 96.6% of participants agreed or strongly agreed with the statement “I have developed an understanding of a science concept as a multi-representational entity” and in response to the question “What was the most useful part of today’s workshop for you?”, typical responses included:

- Using representations to explain a concept. It helps me teach better.
- Representational approaches. It sparked my thinking.
- The hands on practical activities that showed me how to use representations in my own classroom.
- Representations' were new to me and I found this information beneficial to my own knowledge and practice.

After Day 2, in response to the question: What was the most useful part of Day 2, 8% of teachers made comments about Representations intensive pedagogy, such as:

Learning about assessment types that fit representation - style responses.

Representational activities, looking at a diagram from another perspective.

These teachers had accepted the concept of representation as a teaching construct and were beginning to apply it to aspects of their teaching. Teacher project presentations provided rich data showing how teachers applied the representational approach in their classroom. Students work samples demonstrated the benefits of the teaching approach to students learning. Case studies of teachers adopting a representational approach are presented below.

Case Study 1 The teacher used images as an innovative way of introducing the new topic of Cells and having the students identify the topic, through brainstorming and voting. The students came up with ideas of what the new topic is - based only on the images, a list was compiled on board, the images re-viewed and students voted on their choice. This was an effective way of engaging students – and making students think about the aspects of the topic.

Case Study 2 The teacher used her own set of images of various states of matter which students had to classify. The students used syringes, containing wooden dowel, water or air and they had to predict and then test
Empowering teachers through a professional learning program focused on a representation intensive approach whether each syringe could be compressed.

A lot of them believed that the air was seeping out; until we got into the particle model they could understand that the air can be compressed. I did this before we started thinking about matter being made of particles.

The particle model was introduced with a role play.

They held hands. To represent liquid I had every third person in the line only hold with one hand. The particle model representations were then drawn on the board drawing on their experience with

the role play. The other thing I wanted to cover was that particle are nearly always represented as circles... I had them drawing different shapes for particles.

The teacher allowed Year 7 students to use lollies to represent the various states of matter. The representation challenge for each group of three students was to represent each state of matter, As Jess explained, “I brought in a bunch of lollies (marshmallows, M & Ms, snakes), with toothpicks, cardboard and paper. They had to plan what they needed before asking for the items, snakes being used as particles.” The images below show some students models, the teacher encouraged the students to assess the various models. “Once they finished they were required to walk about each of the other representations and ask questions – it was like a forum; they needed to explain why they made the representations as they did.

Figure 1a,b,c,d

Overall the teachers reported that the representational approach was a useful means towards more student-centred teaching. Quotes from the focus group interviews support this conclusion:

I found value in representations as a novel concept of a way of delivering content to students without being a teacher-centre zone. I thought it was a genuine new approach that has a lot of potential.

I think it gives an approach where kids have the freedom to re-imagine concepts and actually show what they do know, instead of copying what we expect.

We already incorporate a lot of things in our teaching but it is different way of thinking about what we already do.

The hands-on activities in the workshop allowed teachers the opportunity to experience the representational approach themselves. They had to create, draw, model and negotiate with peers – as students would do. A main component of the SOSSPL program consisted of teachers using ideas taken from the workshop program to construct and implement a small classroom-based project within one of the classes they normally teach. On Day 3 teachers were expected to showcase their project by providing a presentation to the other participating teachers. Data taken from the presentations provided insight into the nature and assessment by the teachers about their projects. The presentations of classroom projects took up a significant portion of Day 3 of the workshop sequence. The project itself, while some teachers talked of the rush of completing it, depending on the workshop timing, was a strong feature of the program and highly appreciated, and taken seriously.
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It was good participation but, probably the most I’ve got out is from applying it in the classroom.

and forcing myself to do it and come back and present, which I don’t choose necessarily

Many of the teachers reported on substantial teaching sequences and most described sequences that contained elements directly related to the SOSSPL workshops and which represented innovations that extended their normal practice, often involving risk taking and the need to develop new pedagogical skills. Teachers were very open about their experiences and detailed in their descriptions of the sequences and specific in their judgments about the quality of student engagement and learning.

There were many instances in the teachers’ reporting of projects, or sometimes in interviews, in which they described pedagogical challenges raised by the innovations they introduced, and benefits in terms of student engagement and learning. Several teachers commented on the way that by using stimulus material - especially visual images engaged the students, and took the lesson in unknown and unexpected directions. The representational pedagogical approach created different learning and sometimes unknown direction for learning:

I really enjoyed the fact that they got to have a say, and they could then help me with my understanding and what they understood. So, I’d go, “Right we’ll talk about this today.” So, for instance, we talked about human evolution, and used examples such as – showed them the ice – the man that was found in the ice in Italy.

Several teachers recognised the shift in the teacher’s role when using a representational approach, with the need not to tell student the answers, or tell them the scientific facts, recognising the need for students to construct relationships between ideas thereby building their own conceptual understanding. Using a representational pedagogy required planning what and when to say something.

It was really hard; I had to then just keep closing my mouth; don’t talk (I) was trying really hard not to be...feeding them information

But I had to stand back and I just listened.

Teachers used representations in a variety of ways in their classroom projects. Some teachers gave students a choice of representation, for instance when learning about electricity - using the simulations or labwork. They emphasised the need to use a variety of representations.

A key aspect of the representational intensive pedagogy was the need for students to generate and negotiate their constructed representations; having knowledge that a representation is chosen for a purpose that will need to be justified:

Teacher: It’s important for students to justify why they’ve chosen a representation and be clear about the purpose as to which you are doing it... and even that eye flip book...but we’ve always stood there painfully telling them, now put it this way...and do it this way..., so they did it, and really we shouldn’t...I have, we should have stood back and said “You construct your own

representation” and then at the end compare it and see whose is the best.

Teachers linked the representation intensive pedagogy with student-centredness, and were positive about the increased student engagement.

Conclusion

The structure of three full days provided time for the teachers to learn and try out new ideas, and network with other teachers. The project that required teachers to apply some aspect of the pedagogical techniques in their own classroom, and bring back evidence to report on Day 3 was vital to the learning. It forced teachers to adapt and apply what they had learnt, monitor their students learning and reflect on their own teaching. Pitching the professional development so that it meets all teachers’
Empowering teachers through a professional learning program focused on a representation intensive approach needs is challenging, however the concept of a representational intensive pedagogy was new to all the teachers, and provided a wide scope. The student-centred teaching required teacher to take risks, but it built confidence and increased the enthusiasm among teachers and made increased their self-efficacy. The representational pedagogy was new, student-centred tasks took teachers into unknown areas, but it was exciting, and motivating. The results show how teachers had draw on new knowledge and skills and be willing to change their teaching and apply new ideas to their teaching.

References


