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TEACHING AND LEARNING OF PEDAGOGICAL SCIENCES IN PRIMARY SCHOOLS

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ABSTRACT

To help primary school students to better understand science matters, teachers must first be supported to teach science in ways that matter. In moving to this point, this paper identifies the dilemmas and tensions of primary school teacher's face in the teaching of science. The balance is then readdressed through a research-based examination by some of the components underpinning quality science learning and teaching practices, Stories of teachers reshaping their science teaching to enable practical applications of these elements in future practice are shared to illustrate what is possible.

KEYWORDS Enable practise, critical thinking, expertise, skill development, competencies, metacognition, honing, nurturing.

INTRODUCTION

Primary science education centres on the work of teachers and the dilemmas involved in deciding what learning matters for their students and how their professional practice will nurture this learning. As generalists, primary school teachers must determine how, when and where they attend to a range of explicit science curriculum demands while also attempting to balance teaching and learning requirements across all curriculum areas. These decisions are informed by personal and professional experience, including professional understandings of pedagogy and content knowledge, personal thinking and beliefs about the importance of science and ideas about what science matters for their students. Given the individual nature of teacher expertise and the complexity of professional practice it should come as no surprise that there is evidence of a diverse range of approaches to primary science education in Australian primary schools, at the state, school and classroom level. Diverse approaches to science teaching may be inevitable yet two particularly concerning observations, arise from this diversity:

1. Students experience different classroom representations of the nature of science, i.e.,key principles and ideas which provide a description of science as a way of knowing and acting, as well as characteristics of scientific knowledge. Teachers value and attend differently to these principles and as a consequence students may have limited opportunity to develop a consistent and shared understanding about the inherent values and rigor.
2. The amount of time devoted to science is inconsistently allocated, e.g. how and when Opportunities are made available for students to engage in science learning differs across classrooms. This impacts the quality and consistency of student learning experiences.

The interrelated nature of these tensions is important to note. It is because teachers think about science in different ways they therefore work with science in different ways how they understand the nature of science influences, where they find opportunities for science teaching and learning within the context of their classroom. These understandings influence where primary teachers find opportunities to position science within existing pedagogical approaches and position learning within the context of student life experience and relevance of world events Teachers who understand the nature of science as a body of absolute truths, therefore find science difficult to situate within their inquiry approaches to learning. Consequently in these classrooms science may be neglected and / or presented as isolated learning activities. These conditions interrupt and disconnect student learning not only from learning in other areas of the curriculum but also from the context of life experience.

In outlining these dilemmas, it must also be acknowledged that primary teachers have much in the way of expertise to contribute to quality science teaching and learning. Generally in most other areas of the curriculum, they successfully explore pedagogical approaches, which link thinking and skill development across curriculum areas and which situate learning in relevant contexts. In general, primary teachers effectively engage students and encourage learning by supporting students to construct new ideas, share new thinking, generate and record data and collect evidence to challenge and sometimes change existing ideas and understandings. However, while primary teachers nurture critical thinking and important interpersonal learning behaviours, in the main, they do not recognise these acts as part of learning 'science'.

In addressing these tensions and dilemmas, this paper highlights what science education in primary schools could look like by sharing stories of classroom practice where teachers are drawing on aspects of quality science learning and teaching to provide their students with learning opportunities that promote meaningful and consistent representations of science. To get in to this point, however, it is necessary to explore and grapple with how primary school teachers think about science and science teaching, so that we can start to clearly identify what aspects of science matter and how they might translate into learning experiences.

WHAT IS SCIENCE?

Understanding why primary school science is enacted in particular ways relies on understanding how primary teachers think about science and how this thinking relates to their Science teaching. Recent curriculum developments, such as the Australian Curriculum in Science, have explicitly highlighted the need for consistent teaching and learning expectations while also situating science within the overall development of student thinking, understanding and general capabilities. However, the values and intentions of curriculum developers do not always align with the personal practical knowledge of teachers and conversely teachers are not merely the conduits of curriculum. The following exploration and quotes highlight how difficult achieving this alignment is with over forty years of research documenting the need to actively acknowledge and value what teachers bring in terms of the ways they think about science and what this subsequently means in terms of how they think about and enact science learning and teaching.

Teachers don't merely deliver the curriculum. They develop, define it and reinterpret it too. It is what teachers think, what teachers believe and what teachers do at the level of the classroom that ultimately shapes the kind of learning that young people get. The power of teacher thinking in general has been explored by research since the midseventies, and has come to acknowledge that decisions about teaching, classroom dynamics and student learning are strongly related to how teachers construct an individual perception of the reality of their classroom

A number of factors influence how teachers think about science and for primary teachers, as generalist teachers, these include the tendency to focus on non-science studies in their own schooling and teacher preparation which in turn appears to diminish their confidence to teach the sciences. Primary teachers work with science thinking and decision-making is complex.

A SNAP SHOT OF TEACHER THINKING

As eluded to above, it is not surprising that primary teachers respond to the term 'science' in many different ways and this in turn influences what they value as science learning. To further tease out this point, we would like to draw upon a recent experience that the second author had at a curriculum workshop with some of the primary teachers from the same primary school. Four questions were posed to the participating teachers about primary science teaching and learning to gain an insight into their thinking and professional understandings. To scaffold this experience, the teachers completed a post box activity.

This activity is designed to develop student ability to retrieve, restructure and extend personal thinking. The teachers worked in groups, each were assigned with the collection of responses for specific questions. Teachers read and discussed these responses and bundled them according to similar ideas and comments. The responses were recorded to act as a guide for further staff professional learning. Two of the questions posed were particularly relevant to this paper as they explored how teachers thought about the term 'science' and their present approaches to teaching science.

The first question, 'What is science?' required the participating teachers to consider and articulate their own personal understandings of the term 'science'. The responses revealed a range of understandings, such as

- Everything and everywhere
- Understanding our world
- Forming opinions based on evidence
- The study of how and why things work
- The interactions between living things; and,
- Inquiring, questioning and investigating the world around us.

The second question required teachers to state how they were presently approaching the planning and teaching of science by completing the following sentence stem, 'My present approach to science planning and teaching is … Again there were a variety of responses, which were categorised and represented by four main groupings.

1. Limited or no real planning: Comments from this group included that it was difficult to attend to science in quick and easy ways and there were difficulties experienced in terms of finding science in units and also further complicated by time factors, and specialist programs.
2. An inquiry approach: Linking learning across multi-domain (or learning) areas.
3. Stimulating students by using questions: To encourage learning and using topics of interest.
4. Exploring experiments and investigations.

Although these teacher comments can in no way be construed to be a general Representation of primary teacher thinking and practice in relation to science education, they demonstrate that even within one school, teachers think about science in different ways and attend to science using a range of approaches for planning and teaching. The existence of a range of views and approaches has been reflected in larger surveys and data analyses and is one of the reasons why science education in general has for many years been seen as problematic. The data from these previous reports also indicated that in primary schools: teaching time is inconsistently allocated in science teacher's use different planning and teaching strategies to enhance learning; and teachers lack a clear and shared understanding of the learning that they value for their students.

The teaching of the nature of science is consequently variable in primary classrooms across the country and so therefore students' science learning experiences are inconsistent.

WHAT MATTERS IN PRIMARY SCIENCE?

They are shared here as they convey an interesting tension that remains in contemporary primary science education around the relevance of knowledge acquisition and the importance of developing the required attitudes and competencies students need to become scientifically literate. Both of these tensions remain in contemporary science learning and sit prominently in the thinking and work of primary teachers as they struggle to find a way to comfortably position the two intentions in their science teaching. Science is first and foremost a class name for all the natural sciences, ranging from the older physical sciences like astronomy and physics to the newer biological sciences such as genetics. Under the most important fields are mathematics and logic, and under the most important field is science.

There exists a recognisable elementary school science movement aiming to incorporate comprehensive science courses in the primary school programme. The movement exists not only for the obvious reason that science is becoming more and more important in the surroundings of the individual but also because science can be used in important ways in the emotional education of the individual and because of the social need for a scientifically literate lay population. Foremost among the aims of the elementary school science movement must be put the development of a scientific attitudes.

NEW ROLE FOR PRIMARY TEACHERS

It is essential that primary science education assists students to develop a more consistent understanding of the nature of science and better equips them to become scientifically literate citizens, which is considered as an important outcome of science education (Roberts, 2007), while also capturing and engaging their interest in learning science. To achieve such learning outcomes requires inevitable changes to the ways in which science teaching is practiced in primary school classrooms. This will require primary teachers to openly acknowledge the dilemmas and tensions they face when teaching science as an opportunity to re-imagine their role as a teacher of science. While there are numerous elements that could be considered in making sense of this new role, three key documents in the Australian context provide rich and detailed descriptions of what characterizes the strategies, attributes and environments of quality science teaching.

Six characteristics capturing effective science teaching:

1. Students experience a curriculum that is relevant to their lives and interests;
2. Classroom science is linked with the broader community;
3. Students are actively engaged with inquiry, ideas and evidence;
4. Students are challenged to develop and extend meaningful conceptual understandings
5. Assessment facilitates learning and focuses on outcomes that contribute to scientific literacy
6. Information and communication technologies are exploited to enhance learning of science with opportunities to interpret and construct multimodal representations.

BUILDING SUPPORTIVE LEARNING ENVIRONMENTS

A stimulating classroom environment has a positive impact on student learning, most primary teachers would acknowledge that the aesthetic environment in which students work needs to be engaging and this is evident in the displays and visual arrangements that are characteristic of most primary classrooms. Creating a need to know is also an important condition for learning and most primary teachers work in ways to ensure that teaching attends to this important aspect of learning. Affective engagement is also an important part of science learning, contributing to the development of a more purposeful and positive learning environment. In supporting the development of such an environment, talk has always been highly valued in primary

classrooms in terms of literacy and the potential to develop critical thinking and effective communication skills. Talk also has the potential to be an important classroom tool for learning science as it provides an avenue for the sharing, valuing and nurturing of a diverse range of learning.

Making Science Relevant

As Gunstone (1988) stated "learning outcomes depend not only on the learning environment, but also on the knowledge, purposes and motivations the learner brings to the task", therefore learning in science just as in any other area of the curriculum must be focused on understanding and making complete sense of ideas and information. As one of the teachers stated earlier in this paper, the learning demands of students living and working in the 21st century and the context and references by which they make sense of ideas and information is constantly changing. The challenge for contemporary science teaching, in particular primary science teaching, is not so much about students acquiring a range of meaningless concepts or honing the skills needed to access information about these concepts, but in building student capacity to develop critical thinking skills that will assist them in making sense of this information.

This intention aligns very readily with the learning intentions primary teachers hold for other curriculum areas, however, this task is made very difficult if students feel very little connection between the science they are learning in school and their experiences of science in their daily lives. Primary school teachers, in particular, have an important role to play in better engaging students in science as they have the ability to create primary school science lessons that are exciting for students and encourage curiosity about the world.

Assessment That Matters

The "Effective science teaching relies on understanding students pre-existing ideas about science concepts and supporting students to develop more scientific understandings" (Department of Education and Early Childhood Development, 2006). Assessment can be considered as a vital tool for understanding students' ideas and monitoring and evaluating student learning but it is the ways in which teachers use this tool that is crucial (Black & Wiliam, 1998). Teachers should monitor students' developing science understandings by drawing upon and integrating into their practices an array of diagnostic, formative and summative assessment strategies. While this teaching action is common in other areas of primary teaching, such as literacy and mathematics, primary teachers could draw varied assessment approaches for different assessment purposes (e.g. assessment for, of and as learning), to provide their students with opportunities, experiences and feedback that will further enhance their learning.

The students learning in science in different ways, which reflected the different learning needs of their students. It is acknowledged that learning with understanding, as well as learning with interest, is more likely to occur when students are provided with opportunities and support to actively construct their own meanings as opposed to passive acquisition and accumulation of knowledge. Innovative and insightful assessment practices have an important role to play in this active construction of science understanding.

CONCLUSION

In order to ensure meaningful and consistent science learning opportunities at the Primary level, primary teachers must be supported to confront their existing ideas about science and science teaching and learning if they are to begin to articulate the problematic nature of the perceptions they use to define their practice. Getting at the ways that teachers think about science and science education is critical if we are to understand what matters in a primary school context and why. With support, primary teachers may begin to think differently not only about their role as science teachers but also the type of learning they value for their students and the role they want to see their students play as active, critical thinkers and learners in science. Documenting stories of primary school teachers drawing on aspects of quality teaching and learning in primary schools is useful in showcasing to others what is possible and encouraging that shift in thinking. Providing alternative ways of thinking about science teaching may enable primary teachers to relinquish their personal feelings of inadequacy, build on their existing pedagogical strengths and provide a consistent science learning experience for all primary students. In this way primary teachers may come to see new possibilities and opportunities for science learning as well as realizing the potential science learning which exists in the experiences that they presently provide for their students.

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