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Affording and constraining the manifestation of pedagogy in middle years mathematics and science teaching

Linda Darby
Faculty of Education
Deakin University, Burwood
Email: ldar@deakin.edu.au

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ABSTRACT. Researching pedagogy is a complex process due to the multifaceted nature of the way pedagogical knowledge and beliefs develop and are manifested in the classroom. As part of a larger research project, the Improving Middle Years Mathematics and Science (IMYMS) Project, this research is investigating and comparing the effect of subject culture on the pedagogy of mathematics and science teachers. By describing and comparing the way teachers teach and talk about mathematics and science we can begin to understand the relationship between the knowledges that teachers have about how to teach for understanding and features of the subject area within which they operate. This paper explores ideas emerging a trial of a video-stimulated recall technique where a teaching reflected on her teaching in mathematics and science. Insight was gained into affording and constraining conditions that the teacher recognised as influencing her teaching practices.

Introduction

At the broadest level, mathematical, scientific and technological literacy have recently been announced as a Commonwealth Government priority in a recent review of teaching and teacher education published in 2003 entitled Australia’s Teachers: Australia’s Futures. Advancing Innovation, Science, Technology and Mathematics (Department of Education Science and Training, 2003). Mathematics, technology and science education together are positioned as fundamental to developing a Australia as a country that “[realises] its potential as a scientifically and technologically sophisticated nation advancing on the creative and innovative capacity of its people” (Department of Education Science and Training, 2003, p.51). What is it about school mathematics and science and the teaching of them that affords such pairing?

This project emerged out of observations that science and mathematics teaching are often interrelated during discussions about teaching and learning. This may be evident at a local level where science teachers are often expected to be able to teach mathematics, and where timetabling and teacher allotments in some schools are organised in such a way that one teacher teaches both mathematics and science to a group of students in order to encourage an integrated approach that combines mathematics and science (see for
When coupling school mathematics and science in this way, questions emerge about what teachers need to know in order to teach them effectively. What knowledge base are teachers drawing from when teaching mathematics as compared to teaching science? To what extent can this knowledge base be generic, what must be subject specific, and to what degree and under what circumstances can this knowledge be translated from one subject to another? Issues of content, assessment, curriculum, and learning invariably emerge when attempting to understand these questions. Demands imposed on teachers by the uniqueness of the two school disciplines are brought to the fore.

This paper explores some lines of inquiry emerging out of a Ph. D. project focusing on how the subject cultures of mathematics and science influence pedagogy. A preliminary analysis has provided some insight into the relationship between a teacher’s perspectival frameworks and conditions that the teacher recognised as affording and constraining her teaching in mathematics and science. This research is predicated on the imperative of exploring the relationship between classroom practice and factors that bear on this practice. Mathematics and science have been compared in terms of pedagogical requirements (see Hargreaves, 1994; Miller & Baker, 2001; Siskin, 1994), yet little research draws direct comparison between what teaching in mathematics and science looks like in the classroom. Nor is there sufficient understanding of how the subject influences what teachers know about teaching and learning mathematics and science. Research that illuminates the extent to which such knowledge is manifested through classroom teaching across the subjects of mathematics and science is also limited. Such an approach requires strategically seeking and using comparison and contrasts across disciplines (Boaler, Ball, & Even, 2003). Research that uses a comparative lens in order to understand and describe teachers’ pedagogies can be more productive and useful for two reasons. Firstly, looking through a lens that is focused on two subject areas rather than one broadens the scope for laying bare the different elements of pedagogy. Secondly, a comparative lens can be used to develop more informed and sophisticated descriptions of the pedagogical knowledge of teachers, and the factors underpinning the manifestation of such knowledge in the classroom context. The following section outlines the rationale for casting the lens across subject areas with a view to describing pedagogy in a way that takes account of the uniqueness of the subject.

The project

This paper reports on research that is part of a larger research project, the Improving Middle Years Mathematics and Science (IMYMS) Project, aiming to improve middle years mathematics and science using a framework that describes effective teaching and learning in mathematics and science. The framework is modelled on recent research into effective teaching and learning in science coming out of the Science in Schools (SIS) Project (Tytler & Waldrip, 2001). In the SIS Project, effective teaching and learning were described by the SIS components of effective teaching and learning (Tytler, 2004), and

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1 The IMYMS Project to be undertaken by Russell Tytler, Susie Groves and Annette Gough of Deakin University and funded by the Australian Research Council Linkage Grant with the Victorian Department of Education and Training (DE&T). Funding was granted in 2003. My PhD is one of two Australian Postdoctoral Award (Industry) awarded through this Grant.
these formed the basis for teacher reflection and change. The potential for the SIS framework to be extended into other subject areas is being investigated by the IMYMS Project. The IMYMS Project extended the SIS component framework to include both mathematics and science by developing a set of components of effective teaching and learning for mathematics and science, the IMYMS components. The IMYMS project allows teachers to reflect on their teaching. In any change process, reflection is important. Exhortation of teachers to adopt new practices is more successful when there is assistance for teachers to reflect on the principles behind these practices (Alexander, 1992, referred to in Askew 1999). Important also is the opportunity to reflect on their mathematical and pedagogical purposes behind classroom practice (Askew, 1999). Van Manen (1982) argues that “pedagogical reflection bestows the adult with the opportunity to be fundamentally accountable for his educative work with children, while it also enables him to be accountable to himself as pedagogue” (p.283). Although I am not specifically looking at the change in pedagogy, this investigation attempts to promote and access teacher thinking while teachers are actively reflecting on their practice.

Subject specific versus generic descriptions of pedagogy

Subject matter disciplines have received varied prominence in educational research over the past century (Shulman & Quinlan, 1996; Shulman & Sherin, 2004). Various curriculum models underpin Australian state education systems that to some extent reflect a re-thinking of the purpose of the “subject”. These models are informed by research focused on a contemporary view of the purpose of schooling that has generated and reported on a shift in teaching practices in school mathematics and science.

Further, science and mathematics generally receive different degrees of prominence at primary and secondary levels. Where at the primary level mathematics is taught most days of the school week, science content is often accommodated through integrated units based on themes (Tytler, Smith, Grover, & Brown, 1999). As with the British primary education model (Acker, 1997), pedagogy at this level in Australia often focuses on child-centred teaching approaches, and generic pedagogical knowledge of primary teachers is often more highly nurtured than at the secondary level. At the secondary level, a tradition of subject specialisation of mathematics and science has contributed to a tendency to promote pedagogy appropriate for specific areas of content.

Gardner (2004) states that disciplines are “the best answers that human beings have been able to give to fundamental questions about who we are, physically, biologically, and socially” (p.233). They are distinctive in terms of moves, genres, syntax and content, the mastery of which takes time. However, historically, research in teaching and learning has regarded subject matter disciplines in varied ways, “as the organizing framework for investigation and implementation” (Shulman & Sherin, 2004, p.135) or as secondary to “generic principles of instruction that could transcend disciplinary boundaries” (Shulman & Sherin, 2004, p.135) to the extent that content areas nearly disappeared. Today in the US, Gardner identifies that disciplines are being threatened in two ways, firstly by “facts, which are discipline-neutral subject matter, and which serve as just a textbook convenience” (p.233), and secondly by “interdisciplinarity, which often ignores and obscures disciplinary differences” (p.233). These pressures are evident in the Australian context where, in many classrooms, content is the focus of instruction, and
where the notion of interdisciplinary approaches to broad scale and localised curriculum development are being explored.

What does this mean for science and mathematics education? In a review of subject matter, Shulman and Quinlan projected in 1996 that subject matter would again take prominence in determining school curriculum, but that what would count as subject matter would be shaped by the work of scholars in creating the knowledge and of citizens and professional practitioners who use and enjoy the knowledge in the real world play a significant role in defining what counts as subject matter. The social contexts or communities within which the knowledge is discovered and used will become part of the definition of how classrooms are organised for its study. And epistemological questions will finally reach parity with questions of substance in characterising the curriculum. (p.421)

Shulman and Quinlan’s (1996) projections were not unfounded. There was a considerable amount of evidence leading up to 1996 of student dissatisfaction with school, especially with what was being offered in the middle years (Anderman & Maehr, 1994; Beane, 1990; Sizer, 1994). There was mounting evidence to support a change in direction of curricula and syllabuses to recognise the unique needs of middle years students.

The current reform in the middle years of schooling reflects a modified emphasis of subjects where the purpose of the subject matter is as the context for delivering an alternative curriculum concerned with “many of the communicative, expressive, thinking, affective, moral and social experiences which can provide students with impetus to their holistic development as young adults” (Arnold, 2000). Arnold goes on to say that middle school curricula and syllabuses should “reflect integrated approaches emanating from collaboration between teachers of different subjects and between the teachers with their students” (p.4). The New Basics curriculum model being trialled in Queensland represents such an integrated framework for curriculum (see Matters, 2001, for a review of the New Basics trial), pedagogy and assessment, and signals a move towards generic description of pedagogy. The framework incorporates Productive Pedagogies, derived from Newman’s construct of authentic pedagogy, and Rich Tasks that allow students to “display their understandings, knowledge and skills through performance on transdisciplinary activities that have an obvious connection to the real world” (Matters, 2001, p.2).

Gardner’s (2001) approach to what is required for purposeful education is not so much from the perspective of integration of subjects, but more from a perspective that the disciplines provide the context for in-depth study of an area of content and where the pressure to get through the curriculum is replaced with opportunities to develop a “rounded, three-dimensional familiarity with a subject” (Gardner, 2001, p.5). The subject matter, therefore, remains the context for teachers’ knowledge about teaching and learning, and a tool for drawing out pedagogical knowledge.

In the face of attempts to move towards generic descriptions of pedagogy, it is important to understand how the subjects play a role in determining pedagogy. Is it possible to describe teaching of mathematics and science without recognising differences inherent in the realms of knowledge that distinguish the disciplines? In order to understand the benefits and limitations of defining pedagogy in generic terms there is a need to first recognise and ascertain how and why teachers’ pedagogy may be different.
across subject areas. What is common about teacher practice that affords generic pedagogical description across disciplines? At what point do such generic models become redundant in guiding pedagogy? What is perceived as “common” may in fact only be common in terms of language but have different meanings behind the language or imply different purposes or intentions for teaching and learning.

To Shulman, Gardner and others, it is clear that subject matter matters:

It is not only the subject qua discipline that matters. The subject matter, which is the subject transformed, interpreted and arranged for purposes of teaching and learning, matters. (Shulman and Quinlan, 1996, p.420)

The subject matter is arguably the defining element of the culture of a subject (Siskin, 1994). According to Shulman and Quinlan’s projection from 1996, “[m]uch of the educational psychologists’ work will involve inquiries into the advantages of different strategies for transforming subject into subject matter” (p.421). But in what ways does the subject culture within which a teacher operates influence the way he or she teaches the subject matter? Indeed, Stodolsky (1988) noticed striking differences in patterns of instruction in upper primary classrooms that he considered to be a function of the subject matter. My research will build on this accumulated body of descriptions about how teachers transform the mathematics and science subject matter (a process calling on what is often referred to as “pedagogical content knowledge”) for students by investigating how the subject cultures influence their teaching.

Culture is socially embedded and socially constructed, therefore, descriptions of a teacher’s practice are enlightened by drawing on his or her ideas, beliefs and values about the subject areas within which they operate. A teacher’s practice is also probably dependent on the experiences that the teacher has had with the subject or discipline. These experiences are not necessarily related to exposure at university level. For example, Askew’s research into teacher orientation of effective mathematics teachers showed that mathematical qualifications and initial training are not strongly correlated to highly effective teaching practices. Other factors, such as beliefs and understandings underpinning teaching (Askew, 1999) and career trajectory (Siskin, 1994), have been found to be cogent in determining how teachers approach teaching and learning. There is a sense that teachers are inducted into the culture of the subject through their experiences. For example, research on the effectiveness of science and mathematics based professional development for primary teachers by Tytler and others (1999) reported that the purpose of professional development for teachers relatively inexperienced in a content area is “to induct them into the culture surrounding the content, or into new ways of looking at it” (p.210). For science, this meant productive activities as opposed to “disembodied content knowledge” so that mastery of content could be achieved through the introductory activities that represent the content knowledge. These research outcomes highlight the importance of paying attention to teachers’ experiences of the subject they are teaching. Consequently, in my research I will provide teachers with an opportunity to reflect on their experiences when attempting to make sense of how the culture of the subject influences why they teach the way they do.

**Reseaching the relationship between subject culture and pedagogy**

This study is investigating the relationship between the way the teachers talk about their classroom practice and the culture of the subject. The research is drawing on evidence
from the classroom through classroom observation and video footage of their teaching practices. The research plans to gain a grasp on the knowledge, beliefs and actions of teachers in order to describe not just classroom actions but also the underlying motives, expectations and orientations of teachers. Understanding what teachers know about the teaching act requires understanding the complexity of the teacher’s experiences, incentives, beliefs and perceptions about both teaching and learning. The research is predicated on the assumption that there are relationships between teacher knowledge and beliefs, and their intentions and aims for classroom practice, and seeks to examine how the subject culture is placed in this relationship. Notions of pedagogy and subject culture are therefore pivotal to this study.

Pedagogy

“Pedagogy” is in essence the study and practice of distinguishing what is appropriate and not appropriate to support young people’s learning (van Manen, 1999). The assumption is that there is a relationship between cognition and action such that teacher’s knowledge and beliefs are enacted through classroom practice (Baxter & Lederman, 1999). This set of knowledge and beliefs represents the teacher’s perspectival framework, and is influenced by many factors some of which will be generic and evident in both mathematics and science, others which will be specific to the subject culture. Investigation of pedagogy, therefore, requires looking at both what happens in the classroom and drawing from what the teachers know and believe about what is appropriate and not appropriate for their students in learning mathematics and science. Pedagogy then is particularly useful when taken in a broader sense and not simply in the sense of describing and interpreting practice.

Subject culture

“Subject culture” is socially embedded and socially constructed (Siskin, 1994). The subject culture is considered to be part of the social environment of the teachers, and will be evidenced by the norms, practices and attitudes associated with the subject as described by the teachers participating in the study. The subject culture includes the nature of the school subject, the nature of the knowledge underpinning the subject and the nature of the teaching practices. Teachers experience and contribute to the subject culture. Some elements of the subject culture are endemic, being underpinned by defined and organised academic knowledge, while other elements may be more a matter of habit or tradition, or flow from the perceived purposes of the subject in school. The subject culture comes through into practice via sets of assumptions that may or may not be explicitly understood. The influence of subject culture on pedagogy can be explored by drawing on the experiences of the classroom and allowing teachers to reflect on what affords and constrains teaching in these subjects.

Influences on teachers’ pedagogies in mathematics and science

Teachers are likely to draw from a variety of experiences when reflecting on what influences their pedagogies in mathematics and science. Influences may be related to the subject culture, such as the nature of the foundational knowledge, or they may be independent of the subject culture, such as the work place or teacher personalities. Experiences may be sourced from the classroom, membership of subject departments,
learning teams or other groupings in school, from their personal experiences with the discipline and young people within and outside the school community. This refers to the socialisation of teachers.

Research in the areas of socialisation and teacher’s work has helped to understand what factors come to bear on teachers. Siskin’s (1994) study into how teachers view their workplace explores influences on teachers’ work, flagging that the workplace of teaching can be understood to be open, embedded and socially constructed. Open refers to a variety of influences that contribute to expectations of students and teachers, what is determined to be tolerated and desirable, and these influences are considered to emanate from internal and external sources. The workplace is considered to be embedded within the context of the external influences, for example, external testing. Although such influences are external, teachers participating in networks are able to bring in new ideas or send ideas outwards to policy makers. As a socially constructed workplace, teaching is influenced by external, explicit strategies such as policies and testing, as well as “more complex and subtle influences – the implicit ones of shared cultural understandings” (Siskin, 1994, p. 39).

These explicit and implicit influences are of interest in my study, particularly those “cultural understandings” surrounding the norms, rules and attitudes associated with the teaching of mathematics and science. To understand workplaces as socially constructed focuses attention on the active side of construction where teachers are not conceived as passive workers stripped of power to make decisions about their practice. Rather, a view of a socially constructed workplace enables the explicit and implicit influences to be seen not as determining factors but as “a set of constraining and enabling conditions within which individuals actively and collectively shape meaning, and the practice, of teaching” (Siskin, 1994, p.39). This explains how teachers operating in schools fraught with constraining conditions are still able to build and maintain effective practice.

Gibson’s (1977) Affordance Theory helps to understand how factors in our environment influence us, and act, as Siskin (1994) states in the above paragraph, as constraining and enabling conditions. Those conditions that enable a particular action, attitude or practice are called affordances, while those that are inhibiting or constraining are called constraints. Affordances are being more frequently described in research, especially in areas of design (Dickey, 2003) and educational research. Watson (2003) applies Affordance Theory to understand how learning takes place through perception of, in and interaction with, a mathematical activity environment. Affordances are considered here to be a perceived potential for action; constraints are factors limiting possible interactions with the environment.

In my study, Affordance Theory provides a useful approach for understanding how the teachers talk about the factors that come to bear on their practice. How might the nature of the subject afford or constrain particular practices? How does the culture of the mathematics or science departments at their school, the timetabling, the room allocation, availability of equipment, and the teachers’ beliefs about the role of student and teacher in learning afford or constrain a practice that the teacher asserts is representative of the way they would like to or should teach? Then, how do these things compare between mathematics and science? Generating insight into these questions will help to understand the conditions that exist for teachers in these subject areas and will provide an
opportunity to explore which of those conditions are considered to be specific to and a product of the subject culture, and which are more generic and a product of “school”, “education”, “teaching” and “learning”. Exploring these conditions will require both the teacher and the researcher to draw on valuable and rich experiences of the classroom.

The video-stimulated recall trial

The research extends over two years and will include focus group discussions with teacher involved in the IMYMS Project, and the involvement of 12 teachers of mathematics and science who will be observed, videoed and interviewed using the video-stimulated recall technique. These methods will focus on different dimensions of pedagogy so as to build up an holistic picture of what the teacher is doing, what they believe and why. This paper will draw on data generated through a trial of the video taping and video-stimulated recall (VSR) methods using questions and instructions (see Appendix 1) that were informed by the some initial classroom observations and focus group discussions. The teacher involved in the trial is not a participant of the IMYMS Project but has a reputation for being articulate and reflective about her practice. Sally is a Grade 1/2/3 teacher at a metropolitan school in Melbourne, Victoria who has been involved in science teacher education and science education research for a number of years.

Video-stimulated recall is used to promote reflective discussion of teaching practice. The technique of stimulating reflective dialogue with video playback comes under a variety of names such as “video reflection” (Senger, 1998) and “video-stimulated reflective dialogue” (Moyles, Adams, & Musgrove, 2002). This technique generally involves video taping an event, followed by an interview between the participant and the researcher where the video is replayed to stimulate a discussion. The participant may be directed to comment on the events on the video or to draw on the events to comment on ideas identified by the researcher. Sometimes the remote control is given to the participant and they are asked to fast forward the video to a place where poignant feelings, attitudes, responses, etc. emerge and the participant is encouraged to talk about this (Clarke, 2001). A videoed event can be used as a stimulus for individual or focus group discussion. This method of analysis and reflection have been found to have positive outcomes in promoting teacher reflection surrounding teacher change processes (Senger, 1998). Video-stimulated recall will be employed in my study to promote teacher reflection on how their pedagogy compares across mathematics and science.

To ensure that this technique would proffer the level of reflection I was looking for, it was important that I trial the process. One science and one mathematics lesson were video taped. It was considered unreasonable to expect the Sally, the teacher, to view two complete lessons within an interview setting and be able to respond reflectively rather than reactively to the video representation of her teaching. Instead, Sally was asked to view the videoed lessons privately, reflect on a set of questions (Appendix 1), and then meet with me within two weeks to discuss her reflections. The video was played quietly during the meeting, and was useful for the initial stimulation of discussion and reference to particular events or students. Discussion was not restricted to the interview questions, but the questions provided a fruitful basis for discussing how her pedagogy in mathematics and science compared.
The lessons

Both the mathematics and science lessons were planned to include investigatory activities. The science lesson involved continued investigation of “how air works” where students constructed and tested whirly birds, which involved a rectangle piece of paper split half way down and folded to a T-shape. Students were encouraged to test for the best whirly bird and think about what they might mean by best. Sally asked her students to consider, record, and then share how they think air might be acting on the whirly bird.

The mathematics lesson involved students investigating the covering as square centimetres of banana and mandarin skins. This lesson followed on from a previous lesson where students measured the covering of a peanut’s raincoat. Students predicted the coverage for a peeled mandarin and banana, and then used centimetre graph paper to trace and count the number of square centimetres. The last part of the lessons involved students sharing their strategies for counting and problems or difficulties they encountered.

Sally’s thinking about affordances and constraints in Mathematics and science teaching

During the VSR interview, Sally acknowledged that she “really had to think about the differences in my approach to maths and science because on the surface they look similar”. The commentary of the different phases of the lesson profited some valuable insights into her intentions for her pedagogical actions. A number of dimensions to her pedagogy came into view as Sally reflected on the lessons, dimensions relating to her views about maths and science and her general approach and orientation to education of children. This tapestry of knowledge, beliefs and sets of assumptions that underpinned her practice in mathematics and science was enriched by drawing comparisons between the two subjects, particularly in the areas of her orientation to teaching, what the subjects of mathematics and science offered her students, the potential and nature of problem solving in both subjects, and the role of relational issues in creating and maintaining a quality classroom. Through these comparisons emerged a sense of which parts of her pedagogy that Sally considered to transcend subject boundaries, and others that were more related to the nature of the mathematics and science. Affordances and constraints also emerged.

Sally has a strong emphasis on “thinking” in her classroom. In the science lesson the students were making whirly birds as part of a series of activities relating to the concept of “how air works”. The purpose of the first part of the lesson was to

*to pose themselves problems, like what will we mean by best. And then the other skill of being able to compare and control variables was an underlying one, which I will revisit and revisit and revisit. I didn’t expect them to get it really. But if I have the skills as the major focus, the skill is just the dimension, thinking is the umbrella way I handle the teaching. And the work we were doing was the activity, just o look at how air works, that we know its there. Because at the beginning of this unit not all of them were convinced that there was air there.*

Here the science of “how air works” and the scientific skills of “what will we mean by best” “compare” “control variables” are considered to be the vehicle for enacting a
pedagogy that is underpinned by a “thinking” focus. In Sally’s view, the nature of science itself presents itself as a vehicle for promoting and enabling student’s to think:

I really like science because ... it really does focus on critical thinking and analytical thinking in ways that you can recognise it. And I always have, its not really so highfalutin here as a metacognitive focus, but I’ve always got a thinking focus. And if they were going to say the best one, what on earth could the best one mean?

The focus on thinking skills is not specific to science lessons, but underpins her general approach to teaching. Sally identifies that her background in alternative education contributed to a preference for a “messy” classroom where thinking is promoted and made explicit through the activities that support an emphasis on thinking. She has “very strong expectations that they will be thinking... I like intellectual things and I expect my children to learn to love to think and the biggest compliment I can pay children is that’s terrific thinking.” In mathematics the thinking focus is used in such ways as promoting thinking about strategies that student use or for reflecting on problems they encountered. In this mathematics lesson the students were continuing their exploration of covering and square centimetres by counting the number of square centimetres in mandarin and banana skins. The teacher presented to activity as a problem, students estimated the number of square meters by thinking about a previous activity where they worked out the covering of a raincoat for peanuts, then the teacher provided the students with fruit and graph paper and allowed students to develop their own strategies for calculating the area. Reflection followed, where students were encouraged to think about the process:

how did you think this out, sort of what problems did you find, although that didn’t really come out. But we did have to deal with the problem of bits of squares. But we often unpick it, you know; how did you feel.

The thinking focus is present in mathematics also as “that metacognitive thing of looking at the purpose of the lesson” because she believes that “its sort of a meaningless activity unless you think of the purpose”. The focus on thinking is made explicit for students. A distinctive phase of the mathematics lesson emerges here where the teacher draws attention to the purpose of the task. Without a sense of purpose, the meaning for the students is limited to an activity. This need for purpose evolves out Sally’s perspective on the nature of mathematical knowledge in the lives of her students. In this next quote the teacher compares her view about what mathematics and science have to offer students.

I would do it (direct students to the purpose) more in maths and literacy than in science. Science is more a little bit open. I think with maths and literacy I want them to think of it as useful. But I don’t think of science as utilitarian in the same mechanistic way. I think of it as beautiful and problem solving and of meaning. I don’t think of it as, we’ll just get this done so you know why you are floating. I think of science as much grander sort of. I might say well why might it be useful to know this, but I don’t direct them to the purpose of the skill.

The emphasis here is on mathematics being “utilitarian” and “mechanistic”. In this lesson, the teacher was “wanting to get an idea of covering and the square centimetre, both the attribute of area and what you use to measure it” because the skills make the mathematics useful. This was compared to science, which she would prefer to see in the
centre of everything that she does. Her view of science makes it suitable as a central pillar to much of her teaching of other subjects, such as literacy and mathematics: “I think it’s the core of making sense of the world in a way... It’s got ideas, its got metacognitive aspects, its got attitudes, I really think you can pin so much around it.”

Another aspect of mathematics that emerged during these discussions about the purpose of mathematics is the idea that “maths has not really authentic problems... where you’re using abstract things, symbolic things”. The mathematical problems that she tends to offer students are “separate from” reality, they tend to be “vicarious” and that the “skills are just that one removed from being really in there”. Sally finds this as a constraint in her mathematics teaching as she feels that she is unable to “really enact problem solving things in maths in a really real way. Whereas with science we’re always outside or making a mess.” Sally had thought about how she might be able to provide “real” problems for the students where they work with real things, such as getting students to design and make real ponchos.

But it’s very hard to get those things enacted, and then I get nervous about the AIMS testing. So I am constrained by the need in maths for certain levels to be attained because I have to write a report. I find that very nerve racking.

The constraining condition of the vicariousness of mathematical problem solving is closely aligned to another constraint. Sally recognises that the assessment itself, nor a mandatory “early years interview”, are not constraints in themselves as she recognises that they present a “good guide” of student progress. These external influences create a condition where she feels that she is “constrained by a sense of children having to acquire a skill”. This constraint is absent from science because assessment is less tight and focuses only on attitudes towards science, such as

withholding judgement, being able to hypothesise, being able to draw inferences – all of those things that are important to me as skills, but I’m not going to have to mark them on a role, and nobody is going to say your child is able to do [a particular] test.

The teacher often expanded on what she was doing in the classroom by providing rich anecdotes of the children. I flagged this “relational” emphasis as something that I would like to explore but felt that I had little scope to explore at this stage. However, the teacher spoke passionately about how this relational dimension underpinned all that she did, and that it is definitely not manifested differently in different subjects.

It is the absolute core of what I am doing and the subject matter just sits on top. ... I just feel really confident about that underlying everything I do. Because its so important to me.

I asked Sally what the relationship was between the subject matter and the relational aspect in order to get a sense of whether the relational emphasis was manifested in particular ways in mathematics and science. She talked about these relational issues from two levels, one where the teacher can trust the students to “do stuff and wander around the classroom and wander around with scissors at that basic level”. At a much deeper level, she said that “in science I trust these kids to learn in that way and I know children
learn by being, having their sleeves rolled up”. These relational issues are, therefore, closely associated with Sally’s desire to promote a thinking environment and her knowledge about what children need to learn, being able to distinguish what is an is not appropriate for young people’s learning.

I think the nature of science lets me enact the way I feel the relationship between teacher and learner is most markedly. So I mean maths does it as well. It underpins my, the way I ask children to do things, its not very lockstep... I’ll put up three or four levels of maths, in a cognitive hierarchy of the ideas of subtraction. And you choose to do which list, you choose to work where you would be most interested. Not what you can do, but where you would be interested to try it. And that’s why I say it’s a very academic classroom because no one is locked into CSF levels, or even grade levels. And I have children who are zooming along, propelled by themselves, but that’s because the relationship is there. I expect you to challenge yourselves, I expect you to be interested, and have a good time as well. I don’t think it differs from subject matter to subject matter. I think it just underpins how I approach the way people learn things.

The relationship dimension to Sally’s pedagogy appears to not only underpin her approach to the classroom, but it provides the fine threads that draw the various dimensions together: her views about mathematics and science teaching, her approach to the quality classroom and what children need to learn, her expectations of students of how students approach their own thinking.

Sally recognised here that the nature of science is an enabling condition in creating this relationship, as it underpins her expectations of students, such as to think in a certain way. Earlier in the interview we had discussed what it was about science that enabled her to do such open investigations. She said that her view of science was that it is “open ended but all hanging on some really clear concepts. I get a lot of confidence for the fact that there are science concepts to hang it on”. She works at a level where these concepts are “not problematic, they’re agreed on. I like the fact that they exist and I can explore them in lots of ways”. They present a scaffold for planning so that planning can be “concept driven, not activity driven, I’ve got that key concept of properties of air running all the way through, so I’m building from one concept to another.” By comparison, mathematics she finds to be very skill driven, “acquisition of skills, not playing around with really interesting concepts.” In science, then, an affordance was her view of science itself, “because you can have that view”.

Another affordance that Sally recognised was the “culture of the school”. This affordance was not related to her teaching in mathematics and science per se, but provided autonomy in her professional practice.

It’s a very open school. Teachers teach the way they want to. So the way I teach, the appearance of my classroom and the things I allow my children to do or the fact that we are often outside, I think that I am in a really good environment in terms of education. It enables me that sort of freedom. I have a very responsive principal and I’ve worked carefully to, this is my fourth year at the school and I have won the confidence of my colleagues... They totally accept my particular style of teaching. So I am very supported by my educational community.
It is understandable that Sally would recognise this supportive nature of the school culture as affording. As was illustrated by her views about relationship in teaching, her approach to teaching is promote an environment where children have the freedom to explore for themselves and the freedom to work where they are interested. The nature of science presents a way of thinking about the world that she loves because it allows students to explore things freely. The conditions surrounding problem solving in mathematics and the external push to move through the skills for reporting purposes because these conditions act together to direct the teacher towards making decisions that move her away from “real” problems. Reflected in all of these is a common thread of freedom. In the same vain, the supportive school environment that Sally has actively forged empowers Sally to provide for her students an education that is congruent with what she values as being appropriate for her students.

Discussion

Through this reading of Sally’s response to her videoed lessons, the rich tapestry of beliefs, knowledge, and assumptions underpinning her practice provided a context for understanding why certain conditions in her social setting and perspectival framework acted to afford or constrain classroom practice. These conditions did not act on Sally by preventing or effecting a particular pedagogy. In general, pedagogy is not *fait accompli* because these conditions exist, nor does the absence of these conditions mean that the manifestation of pedagogy in the classroom will necessarily be any different, or that all teachers within the same environment will necessarily recognise the same conditions. What these conditions represent are perceived factors in the cultural milieu of the teacher that influence how that teacher makes choices about what they do in the classroom. The constraints that Sally recognised did not act on her in such a way that disempowered her from determining what and how she taught, such as how she could enact problem solving in the classroom. They did not make it difficult, “just different”, she said. There is a sense that they work against her preferred way of teaching, but the emphasis is really on how the teacher manages to work in spite of these constraints. On the other hand, affordances enabled and supported her pedagogical moves, as was clearly evident in the way the school culture supported enacting pedagogy congruent with her pedagogical beliefs and values.

This framework of affordances and constraints has been useful in providing insight into what this teacher perceived as influential in her social setting, especially because the framework was set against the broader canvass of her pedagogies in mathematics and science. A simple description of each tells little about why certain factors may be acting as an affordance or constraint. The framework has the potential for generating further insight into the reasons underpinning particular pedagogical moves and genres that become manifested in the classroom in mathematics and science. Efforts to compare pedagogy in mathematics and science can be greatly enhanced by looking at this very deep level so that pedagogical description takes into account the different conditions that act on teachers as they make pedagogical choices. In a teacher change process such as the IMYMS Project, encouraging teachers to bring to the fore those affording and constraining conditions may empower teachers to make choices about their pedagogy that work in spite of, within or even create change these conditions in their school setting.
**Where to now?**

This research is in its early stages. What has become evident in this preliminary analysis is the complexity of the perspectival frameworks that underpin what the teacher does in the classroom. It will be important to allow the various dimensions of each teacher to emerge in a way that is true to what they recognise as influential on their teaching. What has not been presented in this paper is the variety of influences that Sally recalled as influencing her teaching practice in mathematics and science, such as her education training where she became a “convert” to science education and the influence of one lecturer who fostered a love of science. These influences help to explain how pedagogy develops historically and socially and why certain choices are made in the day to day practice of teaching, planning and assessing.

Over the next year and a half, classroom observations and teacher interviews will focus on exploring pedagogy in the broad sense and not simply in the sense of describing and interpreting practice. Those factors that work to afford or constrain practice will be one dimension that will be explored. Sally’s reflections presented many rich statements about her view of and teaching in mathematics in science, some of which were considered generic, others which were considered to be a product of the uniqueness of the subject. It was beyond the scope of this paper to make any assertions or judgements about these views, nor would I want to in any case. The use of video-stimulated recall during this trial provided an effective vehicle for teachers to reflect on and interconnect these views of the subject with the context of the teacher’s experiences of the various cultures that act on the teacher, including the subject cultures of mathematics and science. It is envisioned that what will emerge will be rich accounts of what teachers draw from as they operate across the subjects of mathematics and science.

**References**


Arnold, R. (2000). *Middle years literature review including list of references: A Report for the NSW Board of Studies*.


**APPENDIX 1**

**REFLECTING ON TEACHER PRACTICE**

1. Watch the video.
2. As you watch the video provide a running commentary of your intentions and reasons for actions that may or may not exemplify the way your operate in maths and science.
3. More specifically, break the lesson up into phases and reflect on:
   a. What are your intentions for this lesson? Were these intentions actualised?
   b. How does your role and that of your students change throughout the lesson?
   c. What is the purpose and role of support materials (and people?)
   d. How are concepts/ideas contributed, constructed and used by the students and the teachers?
   e. Thinking about what you know about maths/science and what children need to learn: What is evident in this lesson that manifests what you know? (eg. needs of the students in keeping them engaged with the ideas and activities)
4. In what ways may the “subject culture” of maths or science at your school be evident in this lesson? For example, does there tend to be a certain way of operating, teaching, learning, organising, planning or assessing that distinguishes maths from science?
5. What is common across your maths and science teaching? What do you ensure is in the classroom environment? How is this evident in these lessons?
6. What do you perceive as your role as a maths teacher as compared to a science teacher?
7. What affords (enables) and constrains (gets in the way of) what you consider to be effective teaching in maths and science?
8. Other areas for comparison that may emerge: artefacts/equipment, board work, group work, questioning, planning, interactions with the students, assessment, student engagement.

9. How indicative of your practice was this lesson?