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not taken graduate courses in mathematics. You need to show your mathematical
view points, and present evidences to support your claims about mathematics
teachers in particular." And he said that "that makes your research a mathematics
education research and distinct it from theses in educational psychology, curriculum
theories or such."

This first experience was extremely valuable to me, and helped me to better realize
the sensitivity of mathematicians and setting up the necessary requirements for more
meaningful collaborations among us.

Last, but not the least, I will like to end up saying that mathematicians are not from
Mars and math educators are not from Venus! (Sultan and Artzt, 2005). They all
could live together and collaborate with each other and live happily ever after, if they
try to understand each others concerns, and if they all agree to have “math in the
center” of their activities. Because I do believe that research findings of mathematics
education community should have mathematical identity and have mathematics at
their center stage.

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Research into pedagogy and school change is a high priority in Australia and many
other countries. This paper, which includes some preliminary findings from the
Improving Middle Years Mathematics and Science: The role of subject cultures in
school and teacher change (IMYMS) project, argues that, while there are key
features that are common to quality learning environments across all subject areas,
generic formulations of pedagogy fail to take account of the extent to which the
disciplines being taught shape pedagogy or the contribution of Pedagogical Content
Knowledge (PCK) to effective teaching — i.e. that there really is a need to put
“mathematics in the center”.

INTRODUCTION
Our main game is and always should be pedagogy — teaching and learning in the face-
to-face setting of classrooms. ... At the same time, if we want to change student
outcomes, ... the three message systems — curriculum, pedagogy, assessment — need to
be brought into proper alignment for us to get desired educational results and outcomes.
(Luke, 1999, pp. 3–4)

Research into pedagogy and school change is a high priority in Australia and many
other countries. Recent Australian initiatives such as Queensland’s New Basics
Research Program (see, for example, Education Queensland, 2000), the Victorian
Essential Learning Standards (Victorian Curriculum Assessment Authority, 2005)
and the Tasmanian New Essential Learnings framework (Department of Education
Tasmania, undated) have attempted to break down the barriers between discipline
areas by promoting generic formulations of thinking, learning, and pedagogy, as well
as new ways of organising curriculum and new forms of assessment.

The ways in which such initiatives have dealt with the nexus between traditional
discipline-based curriculum organisation and their new curriculum structures has
varied, as has the extent to which disciplines such as mathematics have been seen as
merely underpinning the new learning frameworks (for example, in the New Basics)
or have been left relatively intact within a broader structure (for example, in the
Victorian Essential Learning Standards).

1 Improving Middle Years Mathematics and Science: The role of subject cultures in school and
teacher change (IMYMS) is funded by an Australian Research Council Linkage Grant, with
Industry Partner the Victorian Department of Education and Training. The Chief Investigators
are Russell Tytler, Susie Groves and Annette Gough.

It is in this climate that the Improving Middle Years Mathematics and Science: The role of subject cultures in school and teacher change (IMYMS) project is investigating the role of mathematics and science knowledge and subject cultures in mediating change processes in the middle years of schooling.

This paper, which includes some preliminary findings from the IMYMS project, will argue that while there are key features that are common to quality learning environments across all subject areas, generic formulations of pedagogy fail to take account of the extent to which “the character of the disciplines being taught” shape pedagogy (Schoenfeld, 2004, p. 237) or the need to blend pedagogical knowledge and content knowledge into Pedagogical Content Knowledge (Shulman, 1986) — i.e. that there really is a need to put “mathematics in the centre”.

GENERIC PEDAGOGIES AND THE DISCIPLINE OF MATHEMATICS

A mathematical proof is not the same as a scientific testing of a hypothesis, which is not the same as a historical account or comparison across accounts, which is not the same as a critique in the arts or literature. (Gardner, 2004, p. 234)

An investigation of non-mathematics specific pedagogical frameworks reveals much that resonates with views of what constitutes quality teaching in mathematics. For example, Productive Pedagogies — one of the three conceptual pivots of Queensland’s New Basics Research Program — focusses on four dimensions: Intellectual quality; Connectedness; Supportive classroom environment; and Recognition of difference. Within these, Intellectual quality is characterised by evidence of: Higher order thinking; Deep knowledge; Deep understanding, Substantive conversation; Knowledge as problematic; and Metalanguage (Education Queensland, 2000). All of these, except perhaps the last, would be seen as highly relevant to quality teaching in mathematics.

Similarly, although it is not a pedagogical framework, the notion of Communities of Inquiry — which underpins the Philosophy for Children movement — focusses on the development of skills and dispositions associated with good thinking, reasoning and dialogue; the use of subject matter which is conceptually complex and intriguing, but accessible; and a classroom environment characterised by a sense of common purpose, mutual trust and risk-taking. We have frequently argued (see, for example, Groves & Doig, 2002) that a desirable goal for mathematics education would be that mathematics classrooms function as (mathematical) communities of inquiry. However, mathematics and philosophy are quite different disciplines and the way a community of inquiry might look in a mathematics classroom is likely to be quite different from how it might look in a Philosophy for Children lesson.

For successful teaching to take place, there needs to be a clear view of what is meant by successful learning in a particular discipline. So, for example, Kilpatrick, Swafford, and Findell (2001, p. 116) define mathematical proficiency — their term for what they believe is necessary for successful mathematical learning to take place — as having five interwoven strands: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning and productive disposition.
and learning in science, and the SIS Strategy, a strategic process for planning and implementing change (see, for example, Gough & Tytler, 2001).

Among the research questions being addressed by the project are the extent to which a generic “effective pedagogy” can capture the essence of teaching and learning in mathematics and science, and the links between teachers’ pedagogies in mathematics and science.

A central part of the IMYMS project has been the extension of the SiS Components to produce the IMYMS Components of Effective Teaching and Learning in an attempt to describe effective teaching and learning in mathematics and science (for a full list of the IMYMS Components, see, for example, Groves & Doig, 2005).

This extension of the SiS Components to include mathematics as well as science has resulted in a number of distinct types of changes based on a review of the literature on effective teaching, interviews with “exemplary” mathematics teachers, and extensive discussions among members of the project team. Some of the SiS components were regarded as being equally applicable to mathematics, requiring only minor changes in wording (e.g., Students are encouraged and supported to take responsibility for their learning). Other changes, however, reflected the middle years focus of the project (e.g., The teacher builds positive relationships through knowing and valuing each student); the literature on effective teaching (e.g., The teacher clearly signals high expectations for each student); the teacher interviews (e.g., Persistence and effort are valued and lead to a sense of accomplishment); and our own previous research (e.g., Subject matter is conceptually complex and intriguing, but accessible; see Groves & Doig, 2002).

The changes were often vigorously contested within the project team and the differences between the “character” of mathematics and science were quick to emerge. Of course this was no surprise to the project team, as we were specifically seeking to identify what we are referring to as the role of subject cultures in teacher change.

As part of the project, teachers were asked to not only rate their own teaching in terms of the IMYMS components, but also to rate each component in terms of what they believe to be their importance for either mathematics or science, or separately for each when they taught both subjects (which was the case for all of the primary teachers and a minority of the secondary teachers). Data from late 2005 is just being analysed. However, preliminary analysis of data from 34 primary teachers and 22 secondary mathematics or science teachers in one of the four clusters of schools involved in the project, suggests that these teachers’ views reflect some of the differences identified by the project team. In particular, teachers were more likely to rate the following as very important for mathematics than for science:

- Subject matter is conceptually complex and intriguing, but accessible
- The teacher clearly signals high expectations for each student
- Learners receive feedback to support further learning
- Assessment practices reflect all aspects of the learning program

The first, third and fourth items on this list were the ones most strongly contested within the project team. The second item, however, is somewhat surprising as it was one that was seen by the project team as more prominent in science than in mathematics teaching, while the last two were not seen as being particularly slanted towards either mathematics or science.

There was only one item that teachers were more likely to rate as very important for science than for mathematics — namely:

- Mathematics and science content is linked with students’ lives and interests.

While this was again not surprising, it was surprising that there appeared to be very little difference in these teachers’ views of the importance of the following statement, which the project team and earlier teacher responses had suggested were seen as more important in science:

- The learning program provides opportunities to connect with local and broader communities.

Further analysis of the full set of data will be carried out shortly. However, these examples are given here to illustrate the differences associated with attempting to produce generic descriptions of effective pedagogy for even the two areas of mathematics and science, which are frequently seen as being very closely aligned.

The project has generated significant amounts of data relating to teachers’ beliefs and practices; students’ performance, perceptions and attitudes; and the process of teacher change. It is apparent that the nature of mathematics and science, their purpose and role in both the community and schooling, and the quite different ways in which their curricula are constructed (at least in Australia) lead to quite different pressures on teacher pedagogy, and, for our purposes here, the need to “put mathematics at the centre”.

**CONCLUSION**

Current calls to rethink curriculum and pedagogy based on cross-disciplinary “big ideas” and key elements such as inquiry and reflective thinking, have led to generic formulations of pedagogy and new curriculum structures that replace to varying degrees the traditional disciplines. While there is a need for such cross-disciplinary practices, it is important to take account of the extent to which a deep understanding of mathematical content and processes are central to effective pedagogy.
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