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Pedagogy of Mathematics

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Abstract : *Mathematics pedagogy focuses on the ways in which teachers help their students to understand and be able to do and use mathematics. Teachers may often rely on a variety of instructional materials and resources, including problem booklets, concrete materials, textbooks, computer software, calculators, and so on. Teachers need a well-developed framework for identifying and assessing instructional materials and technological tools, and for learning to use these resources effectively in their instruction. In this paper, the author highlights as to how teachers foster students' use and understanding of the terminology that is endorsed by the wider mathematical community.*

Keywords: *Pedagogy, Teaching Mathematics, Instruction*

Introduction

Mathematics is an important subject in school curriculum. Mathematical understanding influences decision making in all areas of life-private, social, and civil. Mathematics education is a key to increasing the post-school and citizenship opportunities of young people, but today, as in the past, many students struggle with mathematics and become disaffected as they continually encounter obstacles to engagement. It is imperative, therefore, that we understand what effective mathematics teaching looks like-and what teachers can do to break this pattern. The principles outlined in this paper are not stand-alone indicators of best practice: any practice must be understood as nested within a larger network that includes the school, home, community, and wider education system. Teachers will find that some practices are more applicable to their local circumstances than others. Collectively, the principles of mathematics pedagogy must:

- be grounded in the general premise that all students have the right to access education and the specific premise that all have the right to access mathematical culture;
- acknowledge that all students, irrespective of age, can develop positive mathematical identities and become powerful mathematical learners;
- be based on interpersonal respect and sensitivity and be responsive to the multiplicity of cultural heritages, thinking processes, and realities typically found in our classrooms;

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- be focused on optimising a range of desirable academic outcomes that include conceptual understanding, procedural fluency, strategic competence, and adaptive reasoning; and
- be committed to enhancing a range of social outcomes within the mathematics classroom that will contribute to the holistic development of students for productive citizen

The pre service and continuing education of teachers of mathematics should develop teachers' knowledge of and ability to use and evaluate- instructional materials and resources, including technology; ways to represent mathematics concepts and procedures; instructional strategies and classroom organizational models; ways to promote discourse and foster a sense of mathematical community; means for assessing student understanding of mathematics.

Pedagogy and Content Knowledge

The term 'pedagogical approaches' is taken as the unit of analysis and describes the elements of practice characterised not only by regularities but also the uncertainties of practice, both inside and beyond the centre or classroom. We link those practices to achievement outcomes as well as to a range of social and cultural outcomes, including outcomes relating to affect, behaviour, communication, and participation. In addition to what the teacher knows and does, pedagogy, so defined, takes into account the ways of knowing and thinking, language, and discursive registers made available within the physical, social, cultural, historical, and economic community of practice in which the teaching is embedded. Those characteristics extend beyond the centre or classroom to tap into the complex factors associated with family and wh?nau partnerships as well as those associated with institutional leadership and governance.

'Quality' or 'effective' pedagogical approaches are those that achieve their purposes. The exact nature of those purposes is, invariably, the subject of debate ? influenced by perspectives about how things should be at a given time (Krainer, 2005). Polya (1965), for example, pressed for mathematics teachers to teach people to think: "Teaching to think means that the mathematics teachers should not merely impart information, but should try also to develop the ability of the students to use the information imparted" (p. 100). Further back in time, Ballard (1915) wrote:

"We have not yet discovered the extent to which we can trust the pupils. By adopting a general policy of mistrust, by never allowing a child to mark his own, or even another child's exercises, by making no child responsible for anybody's conduct or progress but his own, by retaining all corrective and coercive powers in the teacher's hands, we gain certain advantages; we simplify matters, we minimise the likelihood of abuse of authority, and we cultivate in the pupils the virtue of obedience. But we lose much more than we gain" (p. 19).

The framework presented here (see Figure 1) draws on the above literature, although many aspects have been included after initial analyses of data. The framework is divided into three parts: Clearly PCK includes those aspects which are most clearly a blend of content and pedagogy; Content Knowledge in a Pedagogical Context includes those aspects drawn most directly from content; and Pedagogical Knowledge in a Content Context includes knowledge which has been drawn most directly from pedagogy.

PCK Category	Evident when the teacher …
Clearly PCK	
Teaching Strategies	Discusses or uses strategies or approaches for teaching a mathematical concept
Student Thinking	Discusses or addresses student ways of thinking about a concept or typical levels of understanding
Student Thinking - Misconceptions	Discusses or addresses student misconceptions about a concept
Cognitive Demands of Task	Identifies aspects of the task that affect its complexity
Appropriate and Detailed Representations of Concepts	Describes or demonstrates ways to model or illustrate a concept (can include materials or diagrams)
Knowledge of Resources	Discusses/uses resources available to support teaching
Curriculum Knowledge	Discusses how topics fit into the curriculum
Purpose of Content Knowledge	Discusses reasons for content being included in the curriculum or how it might be used
Content Knowledge in a Pedagogical Context	
Profound Understanding of Fundamental Mathematics	Exhibits deep and thorough conceptual understanding of identified aspects of mathematics
Deconstructing Content to Key Components	Identifies critical mathematical components within a concept that are fundamental for understanding and applying that concept
Mathematical Structure and Connections	Makes connections between concepts and topics, including interdependence of concepts
Procedural Knowledge	Displays skills for solving mathematical problems (conceptual understanding need not be evident)
Methods of Solution	Demonstrates a method for solving a maths problem
Pedagogical Knowledge in a Content Context	
Goals for Learning	Describes a goal for students' learning (may or may not be related to specific mathematics content)
Getting and Maintaining Student Focus	Discusses strategies for engaging students
Classroom Techniques	Discusses generic classroom practices

Figure 1. Framework for analysing Pedagogical Content Knowledge (based on Chick, Baker, Pham & Cheng, 2006).

Pedagogy of Mathematics Teaching

Mathematics pedagogy focuses on the ways in which teachers help their students come to understand and be able to do and use mathematics. This standard identifies several components of pedagogy that are essential to quality teaching. These components act as a series of lenses through which teachers filter their knowledge of mathematics and of students in order to enrich and enhance their teaching of mathematics.

Teachers are responsible for posing worthwhile mathematical tasks. They may choose already developed tasks or may develop their own tasks to focus students' mathematical learning. To do so, they often rely on a variety of instructional materials and resources, including problem booklets, concrete materials, textbooks, computer software, calculators, and so on. Teachers need a well-developed framework for

identifying and assessing instructional materials and technological tools, and for learning to use these resources effectively in their instruction.

Teachers who truly care about their students work hard at developing trusting classroom communities. Equally importantly, they ensure that their classrooms have a strong mathematical focus and that they have high yet realistic expectations about what their students can achieve. In such a climate, students find they are able to think, reason, communicate, reflect upon, and critique the mathematics they encounter; their classroom relationships become a resource for developing their mathematical competencies and identities.

When making sense of ideas, students need opportunities to work both independently and collaboratively. At times they need to be able to think and work quietly, away from the demands of the whole class. At times they need to be in pairs or small groups so that they can share ideas and learn with and from others. And at other times they need to be active participants in purposeful, whole-class discussion, where they have the opportunity to clarify their understanding and be exposed to broader interpretations of the mathematical ideas that are the present focus.

In planning for learning, effective teachers put students' current knowledge and interests at the centre of their instructional decision making. Instead of trying to fix weaknesses and fill gaps, they build on existing proficiencies, adjusting their instruction to meet students' learning needs. Because they view thinking as "understanding in progress", they are able to use their students' thinking as a resource for further learning. Such teachers are responsive both to their students and to the discipline of mathematics.

To make sense of a new concept or skill, students need to be able to connect it to their existing mathematical understandings, in a variety of ways. Tasks that require students to make multiple connections within and across topics help them appreciate the interconnectedness of different mathematical ideas and the relationships that exist between mathematics and real life. When students have opportunities to apply mathematics in everyday contexts, they learn about its value to society and its contribution to other areas of knowledge, and they come to view mathematics as part of their own histories and lives.

Effective teachers foster students' use and understanding of the terminology that is endorsed by the wider mathematical community. They do this by making links between mathematical language, students' intuitive understandings, and the home language. Concepts and technical terms need to be explained and modelled in ways that make sense to students yet are true to the underlying meaning. By carefully distinguishing between terms, teachers make students aware of the variations and subtleties to be found in mathematical language.

Conclusion

In this paper the authors are very keen to do is clarify how patterns of inequality can be countered within the mathematics classroom. These explanations are not intended to be read as prescriptions of how teachers should teach mathematics. Rather, by making clear the principles and characteristics underpinning effective practice, the synthesis is intended to stimulate reflection on mathematics education within and across sectors and to generate productive critique of procedures current within the discipline. Reflection and critique will make visible a new sensibility towards the multiple dimensions of pedagogical practice.

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