TSG 1: New development and trends in mathematics education at pre-school and primary level

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ICME 10 2004

TSG

Topic Study Group 1

Aims and focus

TSG 1 had a broad focus, calling for papers that examined contemporary developments in mathematics education at the preschool and primary level (approximately ages 0 through 12 years). This provided an exciting opportunity to explore issues across the early childhood and school sectors and the team quickly decided to integrate early childhood and school presenters, with sessions organized around common themes, rather than by sector. The range of nationalities of the presenters and the participants in this group also allowed the ideas to be considered as they applied in a number of different contexts. This report highlights the themes that were considered, describes the papers that were presented, and summarises some of the key ideas and issues that arose in the group's discussions.

Key themes

In their chapters on preschool and primary mathematics education in the *Handbook of International Research in Mathematics Education* (English, 2002), Perry and Dockett and Jones, Langrall, Thornton, and Nisbet raise issues about access to powerful mathematical ideas and new mathematical ideas for this age range. These authors are calling for policy makers, curriculum developers and educators to ensure that *all* children in preschool and primary school learn the kind of mathematics that will begin to nurture their lifelong mathematical thinking. Moreover, they see these powerful mathematical ideas extending what has been traditionally thought of as "elementary mathematics" and incorporating new strands such as geometrical reasoning, algebraic thinking, data and chance.

This strong thrust in mathematics education research flowed over into the presentations and discussions in TSG 1 where powerful and new mathematical ideas, along with problem solving, were again key themes. These ideas, and related curriculum considerations, gave rise to a fourth theme on teacher education and development.

Paper presentations and discussions

The TSG began with an introduction by one of the Chairs, *Graham Jones*, followed by a keynote presentation by *Carole Greenes*, from Boston University USA. Greenes outlined the details of a mathematics curriculum for preschool and kindergarten called *Big math for little kids*. The programme capitalizes on a number of key elements: children's knowledge and interests, highlighting the mathematics in routine classroom activities, organizing instruction in which activities are sequenced, incorporating complex mathematical ideas, emphasising mathematical language development and promoting "thinking like a mathematician" (Greenes, 2004, p. 5). Assessment processes were still being developed, but observations of the programme led Greenes to conclude that there had been benefits for children and teachers during its implementation with children showing "some remarkable student competencies" (p. 12).

Papers during the second and third sessions were organized into the four main themes. The issues that arose within each theme are identified here as a series of questions. In the first theme ***powerful mathematical ideas***, *Yukio Sugawara* explained how mathematics lessons and curriculum standards have been developed to foster children's mathematical thinking in a Japanese study. *Jill Waters* and *Lyn English* described mathematical patterning in two early childhood settings in Australia. They discussed the importance of mathematical patterning, and the lack of current research in this field. *Margaret Curry*, *Michael Mitchelmore* and *Lynne Outhred* examined Australian Grade 1-4 children's understanding of length, area and volume and the relationship between them. Their intention was to explore the relationship between the learning of measurement in the three domains, and to gain an understanding of how curriculum in this area could be sequenced. *Christina Misailidou* and *Julian Williams* looked at improving English students' performance on 'ratio' tasks. For students who use an additive approach, several strategies such as working on shared context tasks and using a pictorial representation of the problem, assisted in moving students towards multiplicative thinking.

Issues

- *Patterning* (mathematical reasoning where children recognise or build an arrangement of shapes or numbers that repeat or change in a predictable way, for example, 3, 9, 27) was not only a powerful mathematical idea, it was seen to be fundamental to children's mathematical development. Why is there a scarcity of research on children's development of patterning skills? How do we develop teachers' knowledge of mathematical patterning and their understanding of children's knowledge of patterning?
- Understanding of *length*, *area*, and *volume,* and the relationship between these mathematical ideas was of key importance for young children. How do we develop concepts like unit, unit iteration, and the relation between measure and unit size? How do we use research to assist teachers to foster the notion of unit structure (the pattern formed when the units fill the object to be measured)? How do we enable students to deal with the increasing complexity of the unit structure as we move from length to area to volume?
- The power of *proportional reasoning* is critical to children's mathematical thinking. How do we assist children to move from additive strategies to multiplicative thinking? How do factors like the following facilitate this movement from additive to multiplicative thinking: a sharing context task? pictorial models? grouping strategies?
- In facilitating the learning of all these powerful mathematical ideas there was recognition of the importance of *knowledge-creating* type lessons. How do teachers create or locate tasks to foster this knowledge creation? How can extensions to these tasks be developed? How do we get children to express and discuss their ideas during knowledge creation?

The second theme, ***New mathematical ideas for the early years*** included two presenters from the USA who had been exploring children's algebraic thinking, and when this might be introduced into the curriculum. *Sue Brown* focused on children's algebraic thinking in kindergarten through to Grade 2, and described a number of activities that allowed children to work with arithmetic sequences and equations. *Zhonge Wu* used

teaching experiments with older (5th grade) students "to encourage students to participate in algebraic reasoning and justification for patterning problem situations" (p. 3). This theme also included a paper by *Chrisanthi Skoumpourdi* on probability as a new trend in Greek primary education, and *František Kuřina* from the Czech Republic argued for the importance of geometry in primary school.

Issues

- *Algebraic* thinking (including recognising and building geometric and number patterns, identifying and applying relationships to make predictions, and making and explaining generalizations) is a new strand in elementary mathematics but we are only beginning to understand its potential for young children. What does research tell us about the value of algebraic thinking for young children? How do we encourage children to discover, describe, and develop algebraic patterns? How do teachers organize activities in algebraic thinking that build on children's existing knowledge? How do we enable students to pose their own problems/patterns in algebraic thinking?
- Learning *probability*, which explores and measures the likelihood of random events occurring, is a new experience for young children and their teachers. Why is the study of probability appropriate for the preschool and primary school curriculum? How do we convince teachers that probability is an important learning area for young children? What contexts provide useful learning experiences in probability? (Although the group focused on probability, many of the same issues arise in relation to data analysis).
- *Geometry* is an effective source for young children's mathematical investigations. What is the nature of challenging and open-ended geometrical investigations for young children? What kind of learning environments work best for geometrical investigations with young children? What kinds of professional development for teachers would facilitate challenging investigations in geometry for young children?

Problem solving was the focus of *Tom Lowrie*'s and *Noor Azlan Ahmad Zanzali*'s work. Tom Lowrie examined the influence of cultural artifacts (brochures, menus and bus timetables from a theme park) on Grade 5 Australian children's problematising of problem scenarios (e.g. formulating a budget or constructing a timetable for a family at a theme park). Working with children of a similar age, Noor Azlan Ahmad Zanzali from Malaysia examined Year 5 children's problem-posing abilities based on three different stimuli. He recommended that children should engage in both the posing and solving of problems.

Issues

Problem solving can be a method for creating mathematical engagement and for developing mathematical meaning in young children. How do we use problem solving to achieve an appropriate balance between conceptual knowledge and procedural knowledge? What is the role and value of contexts/ authentic artefacts in problem solving? How does problem solving enable us to make connections among mathematical ideas? How do we use children's voices/experiences in problem solving? What strategies can teachers use to help students gain ownership of problem solving tasks?

The final theme brought together presenters who were exploring ***Trends in teacher education*** at the early childhood and primary school levels. *Shiree Babbington* and *Gregor Lomas* had developed a video, *The magic of mathematics in the early years,* for use with early childhood education students at Auckland College of Education (New Zealand). The video highlights the mathematics in a range of examples of young children's play. *Kwok-cheung Cheung* reported on his work with teachers attending an in-service programme at Macao University. Examples were given of how Gardner's multiple intelligences could be used as a base for planning mathematics teaching in kindergartens. Finally, *Saulius Zybartas* and *Allan Tarp* from Denmark described and illustrated a postmodern approach to elementary mathematics that regards mathematical concepts as culturally constructed names for social practices.

Issues

Teacher education is of prime importance in the development and implementation of curriculum programs in mathematics for early childhood and elementary children. Effective change in curriculum and instruction in mathematics is dependent on the nature of partnerships between policy makers, educators, teachers, parents, and children. Why is it important for numeracy to be linked to notions of context and a sense of holistic learning within cultures? How can teacher education and teacher development programs address the diversity of theoretical perspectives faced by schools and teachers?

One additional paper by *Jenny Young-Loveridge* and *Sally Peters* was presented by distribution on the TSG 1 website. This considered mathematics teaching and learning in early childhood and early school and provided a chronology of events in this area in New Zealand since the early 1990s.

TSG 1 concluded with a plenary session. This comprised two presentations, reports from the paper presentations over the previous two days, and a general discussion of issues arising from the work of the Topic Study Group. The first plenary presentation was by *Mike Askew* from King's College, University of London. His paper shared findings from two large UK studies. The first demonstrated the importance of relationships in the teaching–learning process and explored the connections among child, teacher and the learning of mathematics. The children whose teachers were able to connect with mathematics, and to the children's knowledge, made the greatest gains. The second study confirmed this finding and showed that the peer group was also an important factor in these connections. For example, some children were driven by the dynamics of working with the group.

The final presentation was by Sally Peters from the University of Waikato. Her paper considered the New Zealand situation, where early childhood and school have different histories, curricula and pedagogy. An increased focus on literacy and numeracy in the early school years, with assessment against specific frameworks and levels, contrasted with the integrated and holistic approach of the early childhood curriculum. These differences had led to considerable debate about how connections can be made between children's mathematics learning in early childhood and at school. The paper explored these issues and discussed how teacher awareness of opportunities for mathematical learning in everyday activities, contextualised narrative assessments, and views

of progression that included the range of contexts in which mathematics was used, learning dispositions, and mathematical complexity, could all assist in 'crossing the border' between the sectors.

Conclusion

In the opening address and throughout the ICME-10 conference, there were many references to the beauty and power of mathematics and the need for students at all levels to experience these characteristics of mathematics. TSG 1 focused on students in the early childhood and primary years and there was strong support amongst presenters and participants for rich mathematical experiences, which introduced young children to a broad range of powerful mathematical ideas. Knowledge, skills and attitudes were all considered to be important. In the discussions many insightful questions and responses were raised about appropriate pedagogy for fostering young children's mathematical development. Notwithstanding the many fruitful examples of activities and ideas that were considered, the *Issues* noted above indicate possible directions for further research and development to ensure that all children in the early childhood and primary years gain access to the beauty and the power of mathematics.

Reference

English, L. (Ed.) (2002). *Handbook of international research in mathematics education*. Mahwah, NJ: Lawrence Erlbaum.

This report has been written by Graham Jones and Sally Peters. They are happy to be contacted at Griffith University, g.jones@griffith.edu, or the University of Waikato, speters@waikato.ac.nz, for further information on the work of this TSG.