First Steps in Mathematics

Canadian Edition

Research Development Process

with Complete Bibliography

From Research to the Classroom

The Development of *First Steps in Mathematics*

Throughout the 1980s, researchers in the United Kingdom, such as Malcolm Swan, Alan Bell, and Kath Hart, became increasingly aware that many students were constructing elaborate misconceptions as they learned mathematics. Building on the work of Herbert Ginsberg, Lauren Resnick, and Robbie Case, they sampled several thousand students and noticed that, while these misconceptions might produce correct answers at times, the misconceptions remained very much in play and inevitably developed into larger conceptual gaps. When Margaret Thatcher launched her educational reform in 1988, all students in the United Kingdom participated in standardized testing. This resulted in an even greater body of student work available for analysis. A research team, led by Professor Malcolm Swan (University of Nottingham, Shell Centre), was commissioned to learn more about these misconceptions and the types of tasks that would identify them in order to understand why so many students were having difficulty learning mathematics. Their findings were so intriguing and powerful that Professor Sue Willis (Murdoch University and currently Executive Dean of Education Monash University), one of the researchers, resolved to bring this knowledge back to classroom teachers in her country.

In 1995, the Department of Education and Training in Western Australia commissioned Professor Willis to develop professional development resources for their Kindergarten to grade 8 teachers of mathematics. The $5 million research initiative was to develop system wide expertise in the teaching of mathematics much the same way the *First Steps* literary resource has done for the teaching of literacy.

To assist with the task and to ensure the resource accurately reflected the realities of the classroom, Professor Willis worked with Murdoch University colleagues and classroom teachers. The development team began the project with an extensive literature review of research from around the world. The following bibliography demonstrates the unparalleled breadth of this review and includes findings from longitudinal studies, case studies, studies involving both large and small samplings, and all international math conferences held between 1980 and 1999.

The development team summarized each of these findings individually and placed them on a charted continuum that covered an entire wall. The team then pored over this “wall chart” of international findings, sorting and analyzing the data, looking for patterns and trends in student thinking and understanding. The analysis revealed striking relationships and commonalities: *students all over the world were experiencing the same misconceptions*. Several big conceptual “phases” emerged that underpinned the behaviours and understandings commonly held by students. Each phase described what students could *and* could not do given their level of conceptual understanding. As students entered each phase, with its new sets of behaviours and understandings, they based their new ideas on concepts from the previous phase. If left unchecked, these partial concepts became misconceptions. A wall chart continuum of these conceptual phases was developed for each of the following strands of mathematics: Number, Measurement, Geometry and Space, and Data Management and Probability.

The analysis of the international research also revealed "gaps" that had not yet been explored. So the *First Steps in Mathematics (FsiM)* team developed Diagnostic Tasks, based on the research, to investigate these gaps. They collected over 10 000 student work samples across the range of students, school districts, and grade levels, then modified the tasks and the phase information based on their findings. An additional 2000 work samples were used for validation. With this new information, Professor Willis further adjusted and developed the wall chart continua. A validation study was carried out on each phase using a range of the tasks and showed a valid correlation. Work samples gathered in Canadian schools in 2005, using the *FSiM* Diagnostic Tasks, revealed the same misconceptions and conceptual understandings as students in other countries.

From the wall chart continua, Professor Willis created the *FSiM* Diagnostic Maps of students' conceptual development. Big mathematical ideas also emerged from the wall chart analysis. The team identified these ideas as Key Understandings, and Professor Willis described how they develop in teacher friendly discourse. The team also developed reliable Sample Learning Activities that illuminate the Key Understandings along with any commonly associated misconceptions.

Finally, the team developed and validated a professional development process (the *Getting It Right* strategy based on a "school-based teacher-leader' model) that ensures the effective transference of these ideas into the classroom. (See Lawrence Ingvarson, 'Getting it Right' Symposium Paper 2).

The *FSiM* development team's analysis of this body of international research and subsequent validation of their findings shows that it is possible for *all* students to progress well in mathematics, regardless of socio-economic or geo-political boundaries. Armed with the knowledge of this research through *FSiM*'s professional development resources, teachers are empowered to move beyond the mere symptoms of incorrect answers and treat the causes of why students fail to learn and understand mathematics. This is the impact research can have on the classroom.

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