Developing mathematics learning and teaching in the context of curriculum renewal

Gerry Shiel[a], Thérèse Dooley[b], and Elizabeth Dunphy[b]
[a]*Educational Research Centre, Dublin;* [b] *St Patrick's College, Dublin*

The National Council for Curriculum and Assessment (NCCA) in Ireland recently published two research reports to support the review and redevelopment of the primary school mathematics curriculum for 3 – 8 year olds. The first report (Dunphy, Dooley, Shiel, et al., 2014) focuses on theoretical aspects underpinning mathematics education for young children. The second report (Dooley, Dunphy, Shiel, et al., 2014) is concerned with pedagogical implications. In this paper the authors of the reports synopsize the background to this renewal and the key themes of an emerging curriculum model.

Keywords: curriculum, early years' mathematics, mathematical proficiency, critical transitions, learning paths

Introduction

In Ireland in recent years, there has been significant reform in mathematics education at post-primary level, with the implementation of the 'Project Maths' curriculum between 2008 and 2015. Plans are currently in place to redevelop the primary mathematics curriculum for pre-school and Junior primary school children (3-8 years), and, in the longer term, for Senior primary school children (8-12 years). This paper describes the background to curriculum renewal in terms of four broad but inter-related contexts: the performance context, the pre-school context, the policy context and the curriculum context. Then, an emerging curriculum model that could underpin the redeveloped curriculum for 3-8 year olds is described, including aims and focus, goals, critical ideas and learning paths. The paper concludes by identifying challenges for policy and practice, as well as possible research themes.

The Contexts of Curriculum Reform

Performance Context

Students in Ireland have performed in the average range in recent international assessments of mathematics. In the 2011 Trends in International Mathematics and Science (TIMSS) study, children in Grade 4 in Ireland (10-year olds) had a mean score that was higher than the TIMSS international centre point (Mullis, Martin, Foy & Aurora, 2012). However, 13 countries had significantly higher mean scores, including Singapore, Northern Ireland, England, and the Netherlands. Just 9% of pupils in Ireland performed at the Advanced international TIMSS benchmark, compared with 18% in England, 24% in Northern Ireland, and 43% in Singapore. Close (2013) conducted an in-depth analysis of the performance of students in Ireland on TIMSS 2011 mathematics. He observed that performance in Ireland was stronger on the Number content scale, compared with Geometric Shapes and Measures and Data Display, while performance on items described as mainly requiring Knowing was stronger, compared with Applying and Reasoning. He interpreted these findings as reflecting a strong emphasis, in terms of allocated instructional time, on Number and on lower-order processes in Irish primary classrooms, and a weaker emphasis on problem solving and reasoning. There are some recent positive signs in relation to performance. In the 2014 National Assessment of Mathematics, pupils in Second and Sixth classes (ages 8 and 12 respectively) performed at a significantly higher level than their counterparts in the 2009 National Assessment (Shiel, Kavanagh & Miller, 2014). However, the observed gains were not sufficiently large to assuage ongoing concerns about performance in mathematics among primary-school children, including those living in disadvantage.

Pre-school Context

A significant development in early childhood education in Ireland has been the introduction, by the NCCA, (2009), of a curriculum framework (AISTEAR) that provides guidance to all adults who support young children's learning. The framework focuses on interactions, play and formative assessment, and describes opportunities that can arise for learning mathematics particularly in relation to themes such as Communicating, and Exploring and Thinking. Significantly, the framework overlaps with the early years of primary schooling (most children in Ireland begin their primary schooling at 4 or 5 years of age), giving the possibility of a smooth transition between preschool and primary school.

Another important development has been the provision of a free pre-school year since 2010 for all children in the year prior to school entry. The year is designed to provide support to young children in the key developmental period prior to primary schooling. The introduction of this year has focused attention on the activities of early childhood carers in areas such as numeracy and on their preparation for this work.

Policy Context

In July 2011, the Irish Department of Education and Skills (DES, 2011) issued a National Strategy to Improve Literacy and Numeracy 2011-20, which outlined a range of measures designed to raise standards in literacy and numeracy, not only among adolescents, but also among pre-school and primary school children. Measures in the Strategy which might be expected to impact on mathematics include longer primary and post-primary teacher education courses with more emphasis on teaching mathematics, increased allocation of teaching time to mathematics in schools, a greater emphasis on mathematics (and literacy) across the curriculum, an increased focus on formative and summative assessment, and curriculum redevelopment at primary level. Specific national targets for mathematics were set for sample-based national assessments at primary level and for PISA at post-primary level.

Curriculum Context

A new syllabus in mathematics at post-primary level ('Project Maths') that focuses more strongly on conceptual understanding and problem solving in real-life contexts has been implemented on a phased basis in in Ireland since 2008 (see NCCA, 2012). Project Maths was implemented in response to efforts to make mathematics more relevant to students' lives, and to improve students' conceptual understanding and ability to solve problems. Initial findings on the impact of Project Maths are mixed, with one evaluation study (Jeffes et al., 2013) finding that students in initial or pilot Project Maths schools reported frequently using some of the new processes and activities promoted in Project Maths: using real-life situations, making links between mathematics topics, working in small groups, and using computers. However, these activities were conducted alongside transmissive activities such as reading from textbooks and copying from the board. As Project Maths becomes more strongly embedded in teaching and learning mathematics at post-primary level, there will be a need to ensure synergies with primary-level curricula.

Curriculum Themes

Both research reports for the NCCA are underpinned by a view of mathematics espoused by Hersh (1997), that is "a human activity, a social phenomenon, part of human culture, historically evolved, and intelligible only in a social context" (p. xi). Mathematics is viewed not only as useful and as a way of thinking, seeing and organising the world, but also as aesthetic and worthy of pursuit in its own right (Zevenbergen, Dole, & Wright, 2004). All children, regardless of age, ethnicity, gender or social class, are viewed as having an ability to solve mathematical problems, make sense of the world using mathematics, and communicate their mathematical thinking. From this perspective, and in order to address on-going concerns about mathematics at school level, a curriculum for 3-8 year-old children is critical. This curriculum needs to take account of the different educational settings that children experience during these years. It is also important that there is consistency in the aims, goals and foci of mathematics teaching and learning across different settings. These aspects are described briefly below.

A Key Aim of Mathematics Education: Mathematical Proficiency

Mathematical proficiency has been adopted as a key aim in policy documents on mathematics in many countries. Mathematical proficiency comprises the following five interwoven strands (National Research Council (NRC), 2001, pp. 116 - 133):

- conceptual understanding;
- procedural fluency
- strategic competence
- adaptive reasoning
- productive disposition.

Key to the development of mathematical proficiency is the interdependence and interconnection among the strands. Prominent in the literature, in terms of how the overall aim of mathematical proficiency might be achieved, are ideas around goals, processes and content, critical transitions and learning paths.

Goals

In the research reports, particular emphasis is placed on sociocultural and cognitive perspectives because they are the main perspectives underpinning recent research and developments in early childhood education. Arising from these perspectives and from views on how mathematics is learnt and taught, and the nature of mathematics and its purposes and content is a need to identify new goals for mathematics education. Cai and Howson (2013) maintain that, internationally, it is accepted that both content and process should be emphasized along with an emerging emphasis on higher-order thinking skills. Specific mathematical processes employ higher-order skills and these have been envisaged differently by different researchers in the field - depending on whether they adopt a socio-cultural or more cognitively oriented perspective. For example, Perry and Dockett (2008) emphasize ‘powerful mathematical ideas’ such as mathematization, argumentation, connections, and number sense. They emphasize children’s purposeful use of mathematics in prior-to-school and out-of-school settings and contend that mathematical knowledge is developed through engagement in mathematical processes. Perry and Dockett’s powerful ideas combine processes and content with processes foregrounded. Meanwhile researchers - particularly in the US - focus more on ‘big ideas’. Sarama and Clements (2009) focus on twelve big ideas. One of their big ideas is counting, that is, finding out how many are in a collection. It seems that their big ideas focus on content but they stress that processes and attitudes are important in each goal. However, in their approach, processes are implicit rather than explicit. In the NCCA research reports, it is suggested that communicating, reasoning, argumentation, justifying, generalising, representing, problem-solving, and connecting – processes linked with mathematization (NRC, 2009) – should be foregrounded in curriculum documentation and should be central to the mathematical experiences of all children.

Critical Transitions

Goals for mathematics learning can be broken down into different levels of detail. For example, Sarama and Clements (2009) specify accompanying ideas that indicate important insights in relation to children’s understanding of a big idea. Simon (2006) talks about key developmental understandings (KDUs) as “significant landmarks in students’ mathematical development …understandings that account for differences between those learners who show evidence of more sophisticated conceptions from those who exhibit less sophisticated conceptions” (p. 370). Thus, conservation of volume or length is a key developmental understanding in relation to a child’s development of measurement concepts. In documentation linked to the redeveloped mathematics curriculum for 3-8 year olds, critical ideas in each content domain need to be explicated and expressed as narrative descriptors. However, over-specification should be avoided.

Learning Paths

The challenge for teachers is to provide support for children’s progression towards curriculum goals – in this regard, learning paths or trajectories are receiving considerable attention internationally. The literature suggests that, rather than thinking about stages of development (now viewed as outdated), the focus should be on levels of thinking, i.e., different paths towards concept development. They can be conceptualised in different ways depending on the theoretical perspective being applied. The question is whether a learning path is linear and tightly bounded or more circuitous with many interconnecting pathways. For example, Sarama and Clements (2009) present research-based developmental progressions or learning paths and identify the levels of thinking that children progress through as they work towards a goal. Age estimates are also provided as a general guide around when children might develop certain understandings. From the sociocultural perspective, children’s learning paths twist and turn, cross each other, and often use an indirect route to get to a particular landmark. This approach focuses on working in a contingent way with children’s ideas. Proponents of this approach critique the tight specification of learning pathways on the grounds that it does not take into account the situated nature of learning. In the research reports, it is suggested that the use of frameworks that have overly tight specifications are problematic as children develop at different rates and their learning is strongly influenced by culture and experience. In other words, any proposed trajectory should be a hypothetical one.

An Emerging Curriculum Model

Figure 1 below shows an emerging curriculum model. In line with a sociocultural approach to the learning of mathematics, learning paths should be used in a flexible way to posit shifts in mathematical reasoning, i.e. critical ideas in each of the domains. Narrative descriptors of critical ideas can be used to inform planning and assessment. Learning outcomes, relating to content domains and processes, can then be derived from a consideration of the goals, learning paths and narrative descriptors.

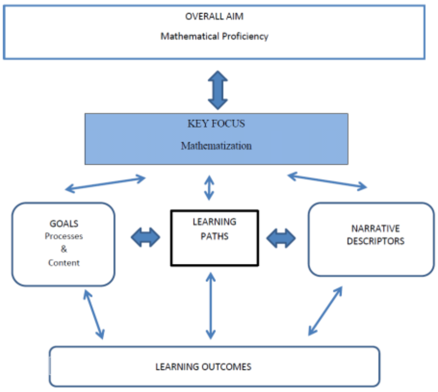

Figure 1: Emerging Curriculum Model

Questions Arising from the Presentation

Following the presentation of this paper (and that by Sue Gifford), members of the audience worked in small groups to discuss associated key issues. The questions they posed included:

1. What sort of professional development is needed to support curriculum change?
2. What ideas do the panel have for making the 'big ideas' in mathematics accessible to practitioners, policy makers and parents?
3. How can we work to support Early Years/Primary/Secondary teachers work together collaboratively in a context of mutual respect|? How can the mathematics education community influence policy and capacity building?

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