DG 3: Mathematics Education – for whom, and what?

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Aims and purpose

Our overarching question was: What is mathematics education *for*? Many answers have validity, and their relative importance for any individual will depend on life experience, intellectual and educational history, and value system. The group discussed the following four focussed questions.

What are the most productive ways of characterising mathematical literacy?

"Mathematical literacy" has become a term to refer, roughly speaking, to the mathematical disposition and proficiency desirable in a citizen. As such it represents a step towards a more widespread access to powerful mathematics, particularly in relation to the practicalities of personal, social, and economic life. However, the term is interpreted in so many different ways that it has become a contested concept. In particular, there is a stark contrast between an interpretation that focuses on "basic skills" or "numeracy" as preparation for the workforce and one that focuses on development of critical tools for, and agency towards, the analysis of social and political issues.

Should school mathematics education be dominated by the discipline of academic mathematics, rather than reflecting the diversity of mathematical practices?

Developments in mathematics education, such as the founding of the field of ethnomathematics by Ubiratan D'Ambrosio, reactions against the Eurocentric narrative of the history of mathematics, the acknowledgment of mathematics as a human activity, and a shift in cognitive psychology to theories of situated cognition, mean that the dominance of mathematics-as-school-subject by mathematics-as-discipline can no longer be taken for granted. A common concern is that school mathematics has scant relevance to the personal and collective lives of the students or the adults they will become.

Can a balance be achieved between a homogenous, monolithic globalised curriculum and the diversity of people and forms of knowledge construction and use?

There are major tensions within mathematics education resulting from globalisation. Should homogenisation of curriculum, like global domination of English, be resisted? Is there an imposition of a single view of humankind, and the associated European construction of rationality? Is it possible to reconcile honouring the mathematics of a culture and dedicating mathematics education to economic progress—in a post-colonial country, for example?

How do we prepare people for a world that is mathematised and demathematised?

Mathematics influences and controls our lives in ways that are not recognised for most people most of the time. Complementary to mathematisation is "demathematisation" whereby mathematical models become hidden within black-box devices. Should a major aim of mathematics education be to prepare people to critically examine such phenomena and react appropriately? Rather than training in routine expertise and simplistic thinking, should mathematics educators aim to nurture adaptive expertise and a sense of understanding complex situations modelled using mathematics?

Publication of background papers

Before the conference, six core papers were posted on the ICME11 website to be read in advance. One was "How much and for whom?", an excerpt from Davis (1999); the others were

invited from participants. Modified versions of these papers, together with others by members of DG3, were subsequently published as the first section of Ernest, Greer, and Sriraman (2009). These papers are: *What is mathematics education for?* (Greer); *Ethical responsibility and the "what" and "why" of mathematics education in a global context* (Atweh); *The dematematising effect of technology: Calling for critical competence* (Gellert & Jablonka); *Mathematical literacy: Issues for engagement from the South African experience of curriculum implementation* (Graven & Venkat); *The purpose of school mathematics: Perspectives of Colombian mathematics teachers* (Agudelo-Valderrama); *Teaching mathematics with and for creativity: An international perspective* (Leikin); *Whose mathematics education? Mathematical discourses as cultural matricide?* (Walls); *The tension between what mathematics education should be and what it is actually for* (Pais); *Mathematics education: For whom?* (Mesquita).

Our discussions

The first session was devoted largely to introductions of the organisers, participants and topic, schedule and logistics, focussed questions, and moderators and reporters for the subgroups that met during the second session. The third session was devoted mainly to reports from those subgroups. As these constituted the most coherent and intense work of the discussion group, the space available is mainly devoted to summaries of the subgroup reports, as follows.

Subgroup 1 (Moderator Terezinha Nunes, Reporter Roza Leikin): What are the most productive ways of characterising mathematical literacy?

The analysis identified key aspects of mathematical literacy (ML):

Definitional attempts

Mathematical literacy (ML) can be defined as a process, a product of learning processes, a teaching approach, a type of curriculum (as, notably, in the case of South Africa), a language that allows communication, and a tool that affords analysis of our physical and cultural environments.

Relationship of mathematical literacy to mathematics

There are contrasting characterisations, between ML as a basic part of mathematics as opposed to ML as intersecting with mathematics but having additional components, and between mathematics for some (for example, professional mathematicians, engineers, economists) as opposed to ML for all. And is it the same ML?

The roles of ML

- A tool for life; a language for communication.
- A component of critical citizenship; tool for understanding events of different kinds; ability to reason about them from critical point of view.
- As basics and beyond.
- For whom, bearing in mind diversity of contexts and approaches for teaching selected mathematical contents. Selected by whom?
- For what – citizenship argument.

Competencies needed for ML

To be mathematically literate, individuals need competencies relating to: mathematical thinking and reasoning, argumentation, and communication; modelling, problem posing and solving; representation, symbols, tools and technology. But they also need confidence in their ability to use mathematics, and comfort with quantitative ideas; an appreciation of mathematics from historical, philosophical, and societal points of view is also highly desirable.

Affective, cultural, and social aspects

ML requires interdisciplinarity—connections to real life, economics, literature, history, arts, architecture, and so on; affords joy, a vision of usefulness, meaningfulness, and beauty of

mathematics; supports intrinsic motivation, self-esteem, self-belief; promotes understanding of the importance of social justice, educational equity, collaboration, and personal integrity.

Subgroup 2 (Moderator Gilah Leder, Reporter Ramash Kapadia) Should school mathematics education be dominated by the discipline of academic mathematics, rather than reflecting the diversity of mathematical practices?

The question provoked lively debate, and it was valuable to have an opportunity to listen to the views of others from a variety of cultural/educational contexts. General themes that emerged included the following.

Questions of access

It was agreed that mathematics should be in the school curriculum. Access, however, varies widely across countries, and political and social factors give rise to differential inclusion, often combined with a demand from marginalised groups for the same access as those with privilege and cultural capital. On a particular issue, there was disagreement in the group about the postulated androcentric nature of mathematics and its implications.

How content is chosen and by whom

Curricular choices depend on value judgments, which depend on the perceived reasons for teaching mathematics, including mathematical literacy, citizenship, opportunity for academic progress, and the power of mathematics. Also discussed was the degree to which curricula reflect these aims.

Beyond pure/formal mathematics

Several participants argued for a better representation of applicable mathematics in school curricula, especially more statistics. Mathematicians (who often have considerable influence) have their own biases, for example, against statistics. Participants mentioned the use of concrete materials, relevance to local issues, and the tension between acknowledging diversity of contexts and relevance to lived experience and potential inequity in the sense of restricting access to the forms of mathematics associated with economic development.

Subgroup 3 (Moderator Carolyn Maher, Reporter Swapna Mukhopadhyay): Can a balance be achieved between a homogenous, monolithic globalised curriculum and the diversity of people and forms of knowledge construction and use?

Meaning of globalisation: charity versus solidarity

The term "globalisation", and how it differs from a new form of colonisation, was discussed at some length. Globalisation, in theory, implies a choice. In practice, the role of formal mathematics education in economic development, and the actions of dominant and affluent groups within and between societies, limit choice. In the above paper by Atweh, he calls for global collaborations rather than a unitary global curriculum, avoiding the imposition of a curriculum developed in one context and uncritically transferred.

Schooling as a social institution

Schools act as a mechanism of social reproduction to sort people into roles within a maintained hierarchy—they promote the willingness to be governed. Yet schools can be a site for change, providing a means for people without power to develop a sense of agency, a disposition to improve their conditions.

Danger of assumption of "Western" superiority

The discussants confronted the dangers in assuming that the approach of industrially advanced nations is best. One participant recalled working in Kenya and realising quickly that what works for her and people like her will not work in Kenya, nor should it. This example acted a strong pivot in discussing globalised education—whose standards should be used?

The possibility of balance? Towards a differentiated and dynamic curriculum

Mathematics, as the most globalised discipline in schools, transcends national and cultural boundaries. With growing emphasis on international comparisons there is a parallel

trend of adopting mathematics curricula associated with what counts as success. Many countries are regulating their national curriculum and as curriculum is getting more and more homogenised, so is the assessment of students' learning. However, counternarratives exist from different standpoints, such as ethnomathematics. Again, globalisation offers the possibility of choice. To address the principles of inclusivity, the group's recommendation was to formulate curriculum as a process, a continuous co-construction accompanied by critique. Since curriculum plays a strong role in developing a sense of identity for learners (including teachers and other adults), it must relate to community. This perspective implies a lateral networking between and among communities rather than the familiar top-down hierarchical model.

Subgroup 4 (Moderator Uwe Gellert, Reporter Brian Greer): How do we prepare people for a world that is mathematized and demathematized?

Living with (de)mathematization

Skovsmose's terms "constructors", "operators" and "consumers" of mathematics in action were used as a framework. Some applications of mathematics are relatively harmless and easy to live with (for example, airline overbooking) whereas others are not (for example, cost-benefit analysis leading to non-recall of a faulty car). Mathematical modelling always has two aspects, namely the mathematical structures invoked, and the phenomenon being modelled, including its moral and other implications; mathematicians tend to focus on the former without paying appropriate attention to the latter. Reification of models may lead to frozen analysis, the cutting off of possibilities and to simplism (as opposed to mindful simplification appropriate to modelling acts).

Implications for education

There are many dangers in education conceived of as technology, such as social (co)construction of ability, ranking, success/failure, organising a school to run with minimal disruption. The teaching of modelling requires not just examples of models but also the construction of models by the students, and the critical analysis of the social processes and impacts of modelling acts. Such an approach would problematise what too often amounts, in school mathematics, to enculturation into the culture of neutrality and the engendering of harmful ways of thinking. Interdisciplinarity is needed to combine the mathematical and human aspects. Given continuing controversy about the use of simple calculators, what are the implications of advanced forms of demathematisation for teaching mathematics (for example, computer algebra, design tools for engineers)?

Reflections and recommendations

In order to promote coherent discussions, the Organising Group put considerable effort into identifying a relatively small number of short papers to be read in advance and focussed questions relating to the central theme. We also thought very carefully about the balance between imposing a structure on the discussions and giving all participants voice. While we were partially successful in these efforts, our successors will be faced with the same challenges. Continuity is key, and we recommend that the organisers of any similar Discussion Group in 2012 take our report as a starting-point towards further developing at least some of the critical issues summarised here.

References

Davis, P. J. (1999). Testing: One, two, three … can you hear me back there? SIAM News (March 22) (Retrieved July 29, 2010 from: www.siam.org/news/news.php?id=719)

Ernest, P., Greer, B., & Sriraman, B. (2009). *Critical issues in mathematics education*. Charlotte, NC: Information Age Publishing.