Chapter 5-2

OTHER CONVENTIONS IN MATHEMATICS AND MATHEMATICS EDUCATION

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Mathematics education is about something, and usually we do not bother to discuss the question of what exactly it is we are talking about because mathematics as an academic discipline is conventionally agreed. There are, of course, disputes about what aspects of mathematics should be emphasised, or what approaches favoured, but the broad characterisation of mathematics is rarely challenged. The current ICMI Study Group is unusual in its focus on difference within the field. The Study Group implicitly acknowledges two major traditions in mathematics and mathematics education: an Eastern one centred in China, and a Western one centred in Europe. Neither of these major traditions are homogeneous, nor are they located in any one place.

The acknowledgement of two conventions, however broad, legitimises the idea that there can be other conventions. This chapter explores such legitimisation by first describing some of the philosophical background to different mathematical world views, then illustrating with two examples, one from The Philippines, and one from Brazil. It then notes the nature of difference within conventional mathematics with the example of Russian mathematics education. Finally, the chapter contextualises the discussion within the politics of knowledge, questioning whether less dominant world views are given due respect for their potential and actual contributions to mathematics and mathematics education.

1. BACKGROUND

Different mathematical approaches, such as those exemplified in Eastern and Western traditions, involve different philosophies and sociologies of knowledge (Ernest, 1994; Restivo, Van Bendegem & Fischer, 1993), and different cognitive and conceptual approaches. Within the worlds of mathematics and of mathematics education, these are masked because there has always, through the history of mathematics, been a tendency to focus on what is common, not on what is different or cannot easily be articulated across cultural boundaries.

Part of this tendency is due to the nature of the subject itself. For a subject that defines itself as pure human thought, and argues for absolute or a priori status for its results, the idea of cultural difference is anathema. A focus on commonalities establishes the illusion (at least) that there is something about the subject that transcends any subjectivity, something about the truths of mathematics that are implicitly known to all. The nature of the classical mathematical task (in the Greek tradition) is the reduction to essential axioms; the search for foundations of the early 19th century was the pursuit of certainty. These grand designs, and the turning to mathematicians in both Eastern and Western traditions as the final arbiters of truth and taxes, has established, in history, the status of acultural (or pan-cultural) knowledge.

It is a major turning point, therefore, to raise, in an international forum, the issue of different mathematical traditions, and the spectre of more fundamental differences within mathematics than those of approach, education, or relationship to society.

It is well acknowledged by anyone with even passing knowledge of the history of mathematics, that contributions to the mainstream of mathematical development have come from many different cultures. It is becoming increasingly recognised, however, that there are cultural components to these well-springs that have been either ignored or misunderstood in the process of assimilation into one "acultural" discipline. The writings of Joseph (2000) have highlighted the unique nature of mathematics in, for example, Indian culture and from different parts of Africa. (Both Indian and African traditions are important exemplars of this theme, but are too large to be adequately treated in this chapter. Readers are referred in the first instance to Joseph (2000) and AMUCHMA—the African Mathematics newsletter).

When mathematical world views are well-established and robust, as they are within Eastern and Western mathematical conventions, there is a possibility of equal and comparative debate about their nature and consequences. However, when the world view is held by a small group, especially one that has been colonised or is in interaction with a larger group, then comparative debate is likely to be difficult and invidious. The dominant paradigms become the measure against which other conventions are judged, and when some of the criteria are aspects like generality or width of application, then conventions based in smaller communities will not count. It should be noted that the effect of dominant conventions operates within mathematics as well as externally.

A more fundamental aspect of this same problem is that the very idea of mathematics is defined by the dominant paradigm – any other system will not be called 'mathematics' and therefore will not be acceptable to 'mathematicians'. A requirement, therefore, for considering the existence and nature of other mathematical world-views is a definition of 'mathematical' which is inclusive and not dependent on Western or Eastern conceptions. An attempt at resolving this problem is D'Ambrosio's "jargons and codes, which clearly encompass [mathematisation], that is the way [people] count, measure, relate and classify, and the way they infer" (D'Ambrosio, 1984). Another is Barton's "'QRS systems', that is, systems by which we make meaning of quantity, relationships or space" (Barton & Frank, 2001).

But the importance of acknowledging and understanding other conceptions and conventions of mathematics is very great. First of all there is the need to embody in our academic activity fundamental humanitarian characteristics such as respect for others, acknowledgement of difference, and basic equality of all humans of access to education and economic health. Every mathematician has a responsibility to help reverse the exploitative history of colonialism and the role played by mathematics in that process (Powell & Frankenstein, 1997).

In addition, there is the educational imperative for all people to increase their mathematical (and hence scientific and technological) literacy so that there is a chance of continued emancipation and increased ability to understand and control aspects of human development (D'Ambrosio, 1994).

Less well recognised, but also vitally important, is the potential of mathematics from other world views to contribute to the broad conventions of mathematics. The history of mathematics teaches us that many major mathematical breakthroughs came from specific cultural origins – indeed the Greek tradition of argumentation that gave rise to the axiomatic method itself is an example. The cultural roots of much mathematics are now not well known, but that does not mean that these origins were unimportant. The very size and integration of the near-universal, conventional form of mathematics of this age is a danger to itself because it increasingly denies the possibility of life-giving contributions from outside itself. For example, the increasing dominance of English as the language of international mathematics precludes ways of thinking that can only be expressed in other languages (Barton, 1999).

It needs to be recognised that cultural difference in mathematical thinking does not just refer to different number systems, or alternative units of measurement, or ways of expressing relationships (although all of these can signal significant mathematical differences, and usually signify significantly different sociological difference – see below). The work of Pinxten, van Dooren, and Soberon, (1987) alerted us to ways of seeing the world mathematically that were different from the Indo-European one. There are other examples of organised systems of mathematical thinking that are not reducible to the conventions of mainstream mathematics, for example Kolam drawings (Ascher, 2002) or Maori weaving patterns categorisation (Barton, 1995). Strong arguments have also been mounted for recognition of the fundamentally mathematical nature of other systems, for example Turnbull (1991) with respect to Pacific navigation systems (see also Gladwin, 1990; Kyselka, 1987; Lewis, 1975), or Cooke (1990) with respect to genealogical systems.

A consideration of other mathematical world views relates to the rise of awareness of the nature of indigenous knowledge. Indigenous knowledge refers to the unique knowledge held by indigenous people about their social, political, cultural and ecological life (Grenier, 1998). It is stored in memories, captured in songs, folklore, proverbs, dances, values, beliefs, rituals, and is expressed in community laws, language and specific practices. Some characteristics include (Alangui, 2002):

- it is embedded, tied to place, or locale;
- it has evolved over time, and experience, and is orally-transmitted;
- it is holistic, and may include beliefs contrary to conventional science;
- it is dynamic.

But indigenous knowledge does not bear categorisation in terms other than those of the indigenous group concerned. The moment a piece of indigenous knowledge is categorised as "biology", "gynaecology" or "mathematics", it has been shifted from its original world view, and becomes something less than it really is in its own cultural context. Indigenous knowledge can only be properly understood from within the world view of that indigenous group. Indigenous knowledge can, of course, be largely understood and used by people outside its originating group, however its proper understanding is inextricably linked to that world view.

In what sense can we talk about mathematical knowledge as arising from indigenous knowledge? Ethnomathematics is different from indigenous knowledge because it is seated in the relationship between a specific cultural group and the world-wide field of mathematics. Even ethnomathematicians who work within their own culture are involved in the mathematical interpretation of that culture. Such activity is still dependent in a theoretical way on some concept of mathematics – a concept that, in its international sense, is not internal to any one culture. The fundamental differences in the parties to this relationship highlight political and equity issues in mathematics education (Knijnik, 1999).

Indigenous knowledge therefore raises issues in the sociology of knowledge: questions of universality, rationality, relativism and reflexivity (Turnbull, 2000; Walkerdine, 1988). The relativist assumptions of both indigenous knowledge and ethnomathematics are at odds with accepted philosophies of mathematics.

The next two sections of this paper give examples of other mathematical traditions: the first is embedded in indigenous knowledge and exemplifies an ethnomathematical approach to mathematics and mathematics learning, the other describes an internal differentiation within mathematics. The final section returns to a consideration of politico-social issues.

2. THE BRAZILIAN LANDLESS MOVEMENT: AN ETHNOMATHEMATICAL PERSPECTIVE

This section presents work which was developed with the Landless Brazilian Movement some time ago (Knijnik, 1998). This national movement involves approximately two hundred thousand families of peasants. At the center of the Landless Movement struggle is the implementation of a Land Reform which will contribute to the democratisation of wealth in a country with the largest concentration of land in the world. One of the dimensions of this struggle is education, where the Landless Movement has made an original contribution, thanks mainly to the ideas of Paulo Freire from the 1960s. The struggle for land can be said to be so amalgamated with education that each reinforces the other. It was the problems that arose in the struggle for land that indicated the need to set education as one of the priorities. Thus the structural struggle for land reform, takes as one of its priorities the education of its members. The Education Sector of the Landless Movement is developing work on primary and secondary schools, the education of youths and adults (with priority to literacy and numeracy), infant education, and in-service and pre-service teacher education.

In this rural educational context marked by cultural difference, mathematics education plays an important role, as it has at its centre the analysis of the interrelations between popular, technical and academic knowledge. This means the assumption of an ethnomathematics approach, understood as (Knijnik, 1997):

> the investigation of the traditions, practices and mathematical concepts of a social group and the pedagogical work which is developed in order for the group to be able to interpret and decode its knowledge; to acquire the knowledge produced by academic Mathematics and to establish comparisons between its knowledge and academic knowledge, thus being able to analyze the power relations involved in the use of both these kinds of knowledge.

This concept opposes the ethnocentric view with which popular cultures have often been treated, and articulates relativistic and legitimising perspectives in examining the mathematical practices of socially subordinated groups. However, it avoids the relativism which would end up producing what Grignon (1992), called "ghetto-isation of the subordinated groups". In the case of Landless Movement, a social movement whose action is in permanent relationship with the dominant groups, this ghetto-isation process would occur if the pedagogical process were limited to the recovery of native knowledge and the glorification of this knowledge.

In the last few years, the young people have begun seeking work alternatives in the cities, thus moving away from the specific struggles of the Movement. This second generation pressure for new possibilities of work and leisure arises now that their material needs are fulfilled. Thus the Landless Movement has sought to implement new projects involving the settlement youths. These needs inspired a project which began with 7th graders of a settlement school, involving the joint action of peasants, students, teachers, and agronomists in constructing pedagogical work in mathematics focused on the productive activities in the settlement. These activities are organised by groups of peasants who carry out all stages of production, from planning to commercialisation.

Initially, the students analysed the bank loan contracts of each group of settlers, to configure the profile of each debt. This was the first opportunity these youths had had of looking at official documents, and it required an understanding of financial mathematics and previously unknown mathematical tools, such as compound interest. The debt profile was presented at meetings with each group of settlers. For the peasants – many of whom were illiterate and most of whom had at most 4 years schooling – this was the first time they had access not only to the final amount to be paid to the bank, but to the details that produced this result.

This first stage triggered further stages, each involving the problematicsation of the production of a specific crop. What follows is an example that began at a joint meeting of the agronomist, students, and teachers, with the settlers of the "Rice Group". This group consists of peasants (originating from a distant region, a region in which soybeans, maize, and bean crops predominate) and of former employees of the farm which, after expropriation by the State, gave rise to the settlement. The characteristics of the soil render it appropriate for rice. Thus, in the group there are women and men for whom rice production is part of their life trajectories, and also those for whom it is a foreign element with which they still have difficulty. As Seu Arnoldo explained: "I am from elsewhere, I have been here for ten years but I have not yet caught up with the pace". The agronomist seeks to understand this "pace", attempting to speed it up by technical qualification.

During the first meeting organised in order to plan the rice crop, one of the questions concerned the amount of land which would be planted. One settler suggested that 30 quadras could be planted, another showed the possibility of planting "up to one colônia". When they heard these terms, one of the students interrupted the discussion to ask how many quadras there were in a colônia. (The expression colônia is used with different meanings in Brazilian rural areas. In this situation the settler was using it to signify 2.5 hectares). The settler answered: "Look, I deal in quadras, they in colônia". The dialogue continued:

> Agronomist: One quadra is 1.7 ha, i.e. 17424 meters.
> Seu Helio (settler): That is saying it in meters, in braças it is 3600 braças.
> Márcio (student): What is braça, Seu Hélio?
> Seu Helio: One braça is 2 meters and 20...is a braça, see? Let's say: cuba here, cuba there... 60 braças like this, the four strips here: see, 60 there, here, 60,60,60,60, to see how it makes a quadra, we will have exactly the 3,600.

Seu Helio was saying that one quadra is the equivalent of a square of 60 braça on each side, that is, a square of 3600 "square braça". The use of measures such as braças in the Brazilian rural environment has been examined by authors like Abreu & Carraher (1989) and Oliveira (1997).

Initially, it appeared that the answers given by the agronomist and the settler were enough for the youths. But when they returned to the classroom the explanations proved unsatisfactory and required more detailed study. The discussion began with what the specialist said, explaining that in the rice plantation, peasants deal mainly with quadra, although there are also those who use colônia as a measure, but he does everything in hectares since the bank loan contracts are in hectares.

Several questions arose: What kind of translation occurs when quadra is expressed in hectares instead of braças? How is colônia translated into quadra? And how do both connect to hectare? How can one establish bridges and shifts between these understandings? What are the effects, in terms of power relations, of these translation processes amongst the Rice Group and in the community?

The pedagogical work sought to problematise these questions. It was not a matter of performing translations which would be limited to numerical equivalencies. This would reduce the study to the demonstration that if a braça is 2.2 meters, then 60 braças are 132 meters, and therefore a quadra is 17424 square meters = 1.7424 ha. An approach which limited itself to this kind of operation would precisely be reducing the work to the formal academic mathematics in which "the practice operates by means of suppression of all aspects of multiple signification" (Walkerdine 1988, p.96). The approach of the project coincides with "the position ... that the object world cannot be known outside the relations of signification in which objects are inscribed" (Walkerdine, 1988, p.119).

The use of specific surface measures produces meanings which are culturally constructed. The imposition of standard measures was not the result of a consensus based on arguments of precision, nor by arguments of universalisation. On the contrary, there are examples of popular revolts such as the "Kilo Revolt "which took place in Brazil in 1871 (Sotto Mayor, 1978). This revolt had as one of its causes the imposition in the country of the French metric system. This part of history is not usually mentioned in the school curriculum, but was part of the work developed in the project, and allowed the construction of bridges between the history of mathematics and mathematics education.

Past and present cultural practices were examined as part of the struggle to impose meaning. Examples of non-official knowledge, vocalised by peasants from different regions with different traditions, were recovered, and were confronted with dominant knowledge, vocalised by the agronomist. In this process the traditions behind quadra, braça, hectare and colônia were also translated.

This episode points to several questions that might be relevant in other social contexts. Peasants, students, teachers and a technician were experiencing the construction of an educational process in which local and more global knowledge interact, where native and technical knowledge are confronted and incorporated. The pedagogical work overflowed the school limits, producing the double movement of making community life penetrate the school at the same time as knowledge produced during this process emanated from the school space. This two-way movement created a pedagogy that did not reinforce the hegemonic ways of learning and teaching mathematics marked by the western, white, urban male culture (Knijnik, 1996).

The pedagogical approach focused on problems of practical and material needs, rather than symbolic control problems, indicating other possibilities in the field of mathematics education, especially in mathematics education that is carried out in different cultural settings, such as the Landless Movement.

3. INTERNAL DIFFERENTIATION—THE CASE OF RUSSIAN MATHEMATICS EDUCATION

Russia is a good example of differentiation within mathematical education. Its special features are determined both by its geographical position (on the border between Europe and Asia), its socio-cultural traditions, and its political structures. Mass mathematics education occurred in Russia in the 20^{th} century and has developed as one of the best in the world. What have been the national features behind such development?

The objective reasons for the intense development of mathematics and mathematics education in Russia were, as in other countries, the necessities of economic and military development. However, being a huge country, Russia had especially strong economic and military motivations because the feudal economy of 19^{th} century Russia needed to cope with the Russian-Japanese war (1905) and two World Wars.

The basis for advanced mathematics education in Russia was the elitist system that existed at the beginning of the 20^{th} century. The elite taught the elite and this education naturally reached high levels. An example is the famous theoretician of space flights Tsiolkovskiy, who reached the pinnacle of physics although he was a schoolteacher in a small city.

Another base was the existence of good textbooks generated by the reforms of Peter Great. In 1725 he founded the Academy of Sciences in Russia and invited famous European mathematicians such as Euler to work there. This not only established a high level of mathematical research in Russia but also resulted in the publication of mathematical textbooks that were to be the basis for many others. From that time Russian mathematics textbooks changed very little. For example, a geometry textbook by Kurganov (based on Euler's own text) was used from 1765 till 1845. This was followed by a textbook by Busse (new version of Kurganov's text), which was in turn followed by one by Kiselev that was based on Busse's work. Kiselev's text was published in 1893 and was in use as the main textbook until 1976 (throughout the socialist revolution).

Mathematics education programmes evolved over more than a century and proved to be successful. Arithmetic calculation, text problems, Euclidean geometry (including 3D-geometry) became the basis of the curriculum. Much attention was paid to development of logic: along with the question "how", the main question was "why". This orientation corresponds to a distinctively Russian way of thinking.

One of the main features of the development of education in Russia is that it was conducted by a strong centralized power. Decisions were made at a very high level and were strongly controlled, particularly after the Socialist Revolution of 1917. In the 1930s, the government decided to implement fast industrialisation, so that a lot of new specialists were needed. The decision was made to intensify fundamental education, and socialist concepts of equality required the development of a common education, rather than an elitist model. Secondary education became available for all and later became obligatory. In mathematics education there was no simplification of programmes. In spite of their high level, the government obliged young people of all regions to try to master mathematics according to these programmes. Many new pedagogical institutes were opened and graduating students had to work for several years where directed by the government. The journal Mathematics in School played a very important role. Its articles were mostly devoted to mathematics itself rather than to methodology.

Assessment was another part of centralized control of knowledge. In the 1930s students took national examinations each year from the 4^th^ grade. In the 1950s they took examinations only after 4^th^, 7^th^ and 10^th^ (last) grades. Now they take examinations after 8^th^ and 11^th^ (last) grades. The examinations in mathematics are in both written (algebra) and oral (geometry) forms. To enter universities or institutes they need to take further special examinations. A special feature of oral examinations at Moscow State University is that they include proofs not only in geometry but also in algebra.

Despite the socialist imperative of equality, mathematics education in Russia was also strongly oriented to the special education of gifted students. An important factor of Russian mathematics education was that high school professors took part in the work with school students. In the socialist period, social activity (without salary) was very much appreciated and even obligatory. For university staff and high level teachers a suitable form of the (necessary) social activity was teaching students extra mathematics in special evening lessons. Such groups were organised in many universities and institutes. To make these lessons interesting, professors either taught those topics that were not considered in secondary schools or dealt with interesting logical and geometry problems. All this contributed to a higher level of mathematics education for top students. Later these ideas transformed into special mathematics classes, and eventually into the development of special mathematics schools in many cities. In 1963 some special mathematical schools with dormitories were opened in universities. These catered for gifted students from the whole country, for example, about 200 students graduated from the special mathematical and physical school of

Moscow State University each year. Since 1963 the Moscow State University organized a Distance Mathematics school for students from the whole of Russia. Since 1970 a special mathematical and physical journal Quant for students has been published.

The idea of competition in production was very popular in the 1930s. The concept also took hold in mathematics. From the beginning many famous Russian mathematicians took part in their organisation. For example, Academician A. N. Kolmogorov was the chairman of several mathematical Olympiads. In 1961 the first All Russian Mathematical Olympiad was organized with several stages: school, region, state, with about 300 school students taking part in the finals in Moscow. Moscow and All Russian mathematical Olympiads have been organised every year since that time, resulting in good results in international competitions.

Since the 1970s several changes have been made in mathematics education curricula. Elements of mathematical analysis, linear algebra, analytical geometry, and geometrical transformations are included, while Euclidean geometry remains the basis. Both geometry and algebra include now more theory than before and less problem solving. School mathematics has become difficult for students. As a result of this and of the democratisation of society, there are different opinions about mathematics education. A vigorous debate is now developing around mathematics education in Russia, and future directions are far from clear.

It can be seen from this short case description that national features have had a considerable influence on the development of both mathematics and mathematics education in Russia. The high level formal mathematics emanating from that country has its genesis in a particular socio-political history. Current debates have developed partly in response to outside interactions. Thus developments internal to mathematics respond to similar circumstances as those of external mathematical knowledge systems.

4. MATHEMATICS EDUCATION AND THE POLITICS OF KNOWLEDGE

The question of cultural difference in mathematics is a question not only from the anthropological standpoint, but also a question about seeking to understand mathematical difference sociologically, including the way differences constitute inequalities.

Thus, in returning to a discussion about the relationship between hegemonic mathematical knowledge transmitted by schools and the mathematical knowledge that is part of the students' culture, we argue that the main issues are those of the politics of knowledge and the politics of identity. Although one of the main purposes of schooling is to assure everybody has access to the knowledge of conventional mathematics, the price to be paid for this is appears to be the erasure of other forms of mathematical knowledge that have been marginalised throughout history. Boaventura dos Santos, when referring to the destruction of the knowledge of a given social group, refers to this as epistemicide (Silva, 2003, p. 196):

The opposition to such suppression cannot depend upon benevolence. What is required is more than mere respect for other modes of dealing mathematically with the world. It is not a matter of the "return" of voices repressed by Eurocentric discourses (Grossberg 1993, p.91). We are interested in this return, but we are aware that it is pregnant with complexity. The contemporary debate in mathematics education has attempted to understand this complexity in order to avoid naïve positions that would lead to folklorising indigenous knowledge, and to benevolent attitudes that would include these forms of knowledge in the school curriculum as long as they stayed on the edges. McDowell (2003), mentions Edward Said's Orientalism, and argues that the author is:

> attempting to open time for listening to a multiplicity of previously silenced voices, voices drowned out by the controlling master narrative. This movement of giving a certain sight to those "blind to other histories" in itself, then, is a form of resistance. Consequently, resisting the discursive hegemony becomes, then, it should be added, a morally significant matter that is shaped by the construction of alternative visions or ways of telling the story that more comprehensively incorporate and retain the distinctiveness of these voices. (p.2)

The articulation of these voices, in the field of mathematics education as elsewhere, is directly connected to the production of social identities. Both the topics that are selected as the object of study, and the theoretical tools which we use with these topics, reinforce certain identities and weaken others. Such identities are neither fixed nor unique, but are subject to our social world. As Woodward (2000, p.14) showed, identity is relational and is connected to social and material conditions, such as the school curriculum. For example, at school we teach the meanings of mathematical reasoning and ways of communicating this reasoning, highlighting those that are "right" and which of them should be ignored because they are not sufficiently important. Thus, for instance, the specific ways in which Brazilian peasants calculate the area of their lands, or the way New Zealand Maoris categorise weaving patterns, are devalued, and are usually silenced in the schooling processes. This creates a dichotomy between "high" and "low" mathematics. This dichotomisation is aligned with the politics of dominant knowledge: it shapes specific identities in teaching other things besides mathematics content. That is, it positions the students in certain places in the social world and not in others. It ends up by excluding particular world views, and thereby reinforces social inequalities.

Ultimately, this is what we mean when we observe the master narrative of academic mathematics reigning alone over the school curriculum, without allowing the presence there of other, non-hegemonic, narratives. This is why it is important to consider other conventions, both within conventional mathematics and external to it.

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