MULTIMATHEMACY

Karen François* & Rik Pinxten**

*Center for Logic and Philosophy of Science, University Brussels (VUB)

** University Ghent

This paper starts from two statements based on a literature review. The first one concerns the learning process and states that learning is situated and socioculturally contextualized. Learning happens in the space of the background and the foreground of the learner in his or her particular environment of experience. This statement is based on the Vygotsky and the cultural psychology approach (Cole, 1996) and on the work of Vithal and Skovsmose (1997). The second statement concerns the drop out of schools. Based on the international comparative research on mathematical skills we claim that the drop out of school of many groups of children (OECD, 2010) has to do with the insufficient learning system at school that fail to fit with the daily background knowledge of the children.

INTRODUCTION

In Pinxten & François (2011) we introduced the concept of multimathemacy (after multiliteracy) to discuss the political agenda of ethnomathematics. We argued that multimathemacy should be the basis of the curriculum in order to guarantee optimal survival value for every learner. We described multimathemacy is an educational perspective that invites the teaching of different cultural insights on counting, proportional thinking, mapping or spatial organization in preschool knowledges. We argued that this view offers bridges between academic mathematics and cultural knowledge traditions for schooling. In this paper we will further elaborate on the theoretical framework and on the learning theories that support our statements on the concept of learning (mathematics) as a situated and socioculturally contextualized process.

Learning mathematics is a particular subset of learning. Hence, it is relevant to look at the learning theories, which are available so far. Since we focus on learning in /of different cultural groups or populations in this paper, we went looking for an inclusive theory of learning. That is to say, one that is sensitive to context, culture and social differences. This means that we hold, as an *a priori*, that learning is a process that happens not only in the brain or even in the organism of a single individual. Rather, we see it as a process of change in the individual in interaction with the social, cultural and environmental contexts. Looking at learning in this way we were driven almost necessarily to the sociocultural learning theories of Vygotsky and other neo-Vygotskian authors, lately synthesised in the cultural psychology theory, namely by Michael Cole. Learning is always 'situated' learning (Lave, 1988; Lave & Wenger, 1991), and through manipulation of the contexts of learning in teaching settings, the process of learning can be influenced substantially.

Secondly, and consistent with the first choice, we focus on the characteristics of all parties in the process, when devising a curriculum and learning strategies. That is to say, the curriculum developers (in this case, the mathematicians trained in Academic Mathematics), the teachers (basically of the same background) and the pupils have their own mental setups when entering the learning process in a mathematics classroom.
We take this seriously and investigate what the input of all of them amounts to. When developing a curriculum and teaching procedures we will take all of these into account.

The basic reason why we feel obliged to go along this track (apart from mere ideological preferences for this or that societal model) is the fact that the drop out in the schooling is consistent and at the same time rather specific. In the overview report of the OECD (2010) two of the key factors are described as "-continuing disparities in scholastic achievement between first and second generation immigrant students and their native peers; -lower *scholastic achievement* and graduation rates for indigenous populations in countries with long history of migration" (OECD, 2010, p. 14, italic in the original). Data from the PISA 2003 and 2006 (OECD, 2005; 2010) show that on average across all participating countries native students perform better in mathematics than first and second-generation immigrants (OECD, 2010, p. 24). This pattern is particularly troubling as it appears that native students perform better than the second-generation immigrants who are born and raised at the same country. At the same time – and part of the explanation of second-generation immigrants' situation – figures indicate that a student coming from a low socioeconomic status is "twice as likely to be among the low achievers" (OECD, 2010, p. 25). Recent studies (Zhao, Valcke, Desoete, Zhu, Sang, and Verhaeghe, 2012) reveal that a large proportion of mathematics performance can be predicted from contextual variables, one of them being the link between the SES of parents and mathematics performance. Of the predictors of mathematics performance at age 10, the effect size of mother's education level is higher than that of father's education level. Mother's educational level is also related to the mathematics score in primary education (Zhao et al., 2012). Zhao et al. (2012) assume that mother's higher educational level implies that mother expects her children to take more responsibility at home and in relation to their thinking and learning.

Concerning indigenous students the challenges identified across all countries (having indigenous populations that pre-date the arrival of European settlers viz. Australia, Canada, New Zealand and the United States) are the following: "difficulty in accessing and receiving the level of early childhood education and care recommended; lower levels of literacy and scholastic achievement; lower rates of graduation; proportionally higher representation in vocational education and training streams than their non-indigenous peers; and lower rates of participation in tertiary education in many of these countries (OECD, 2010, p. 26).

This is some of the most important reasons why the executive board of the OECD states that educational systems have to become more effective and more equitable. These international research findings are confirmed by national research results, e.g. the Council of Australian Governments (COAG) states that indigenous people are the most educationally disadvantaged group within Australia. Their educational outcomes are substantially lower than non-indigenous students. For example, in 2006, 45,3% of the indigenous Australians had completed the 12th grade, compared to 86,3% for non-indigenous Australians (Howard, Cooke, Lowe, & Perry, 2011). If we know that Australians who have not completed the12th grade are less likely to have the same opportunities as those who do, we can speak in terms of inequality and violation of human rights.

We want to understand what is going on, and our proposal is that the learner's perspective is not enough in the focus of mathematics educational programs so far.
PISA research (OECD, 2005, p. 190) shows that high performance in mathematics education consistently links with high scores in reading and science knowledge. At the same time, low performance in school is uniform for a second group of the school population. The gap between both groups seems to consolidate or even widen, rather than narrow over the years. We interpret these results here as corroboration of our main thesis, namely that cultural and social differences between learners do count in education. That is to say, when pupils perform poorly in the dominant language of the mainstream culture in which they participate (which is more or less different from their home language) and in the dominant world view (for which the same can be said), then schooling which disregards in a general way these differences will presumably yield larger gaps between subjects of the dominant social and cultural groups (i.e., middle class white groups) and others. We want to understand what is going on, and our proposal is that the learner's perspective is not enough in the focus of educational programs so far. Here, we concentrate on mathematics education only, starting from a general focus on learning in the first place.

THE LEARNER'S PERSPECTIVE

The learner is not a mere receptive or passive party in our view. Hence, learning theories, which 'situate' the learner and the learning process in contexts will carry our attention, and we will disregard the other ones. In a very general sense, we follow Cole's (1996) synthesis in this respect.
In Vygotsky's (1934/1962) intriguing approach of almost a century ago, learning was first and foremost understood as a dialectical process between a learner and his or her environment. In other words, it was not identified merely with the processes inside the head of the learner or even at the edge of it. For example, in the very powerful stimulus – and response theory (behaviorism in its many versions) learning is studied as the result of the processing of (controllable) stimuli by means of the responses they trigger in an individual. Neither is it equated with a particular form of adaptational action on the part of the individual in his or her biological maturation cycle (as was the case in Piaget's learning theory: Piaget, 1972). Vygotsky and his school broke

away from these approaches and situated the learning processes plainly in the field of interaction between a learner and the physical, social (-historical) and cultural environment or set of contexts.

Such a focus has tremendous consequences for education. First of all, it entails that characteristics of both the learner and the environment matter in the curriculum and in the learning procedures. If the pupil is unable to grasp the point of the learning process, then failure will probably ensue. But if the context is too poor, too far removed from anything understood or recognized by the pupil or in any other way ‘foreign’ to the pupil’s knowledge categories, then failure to learn will also be the result. In line with Bakhtin (1986), Bruner (1984) maintained that you always create or hear about a narrative in terms of your life experiences and background. Giving meaning and creating knowledge of the world is relative and it is dependent on the individual’s past and present experiences.

Secondly, it then becomes important to look for types of matching between the student’s mental setup and background knowledge and the challenges and possible inputs in the context. The latter could be hidden, openly offered, presented as triggers or otherwise entered in the interaction process with the learner. It is clear that learning procedures are in focus here.

Finally, evaluation of learning output stops being the assessment of the pupil’s responses only. It clearly and equally involves the assessment if the success or failure to induce learning by the contexts of the pupil as recent research reveal that a large proportion of mathematics performance can be predicted from contextual variables (Zhao et al., 2012).

When we put the learner in the focus, it follows that we need to ‘flesh out’ the individual learner a bit more to go beyond the trivial. We side with a cognitive theory of the learner, claiming that some parts of the metaphorical ‘black box’ can be filled in a hypothetical, but nevertheless dependable way without losing scientific credibility.

In terms of mathematics education recent research in this area was done by Scandinavian colleagues in the research group of Skovsmose (Alrø, Ravn, & Valero, 2010). Skovsmose, who coined the concept of Critical Mathematics Education (CME) situates mathematics education within a broad social and political context. Indeed to Skovsmose mathematics teaching and learning could aim at developing democratic competencies. This is why CME is concerned with mathematics education for all –independent of color, gender and class. CME is concerned with the practical application of mathematics – being an advanced technological application or an everyday use. It is also concerned with the democratic setting of a classroom situation, with the life in the classroom, and with the critical voice of pupils. A mathematics class has to be a space of learning where ideas are presented and negotiated. Indeed to Skovsmose and Borba (2004) CME is concerned with the development of critical citizenship.

In this social and political embedded learning process, any learner is a subject within historical, social and cultural contexts, from which he or she brings into the learning situation previously gathered concepts, problem solving strategies and learning procedures. These are summed up under the label of 'preschool knowledge'. Obviously, the contents of this category are primarily defined by the worlds of experience of the child: the peer groups, the family, and the physical and sociocultural environment of the child. Hence, street children will differ in their preschool knowledge from Amazonian Indians, from city dwellers in Western Europe, from Aborigines and Torres Strait Islanders in Australia, or from peasant children in rural China.

A further sophistication introduces the distinction between 'background knowledge' and 'foreground knowledge'. It was Vithal and Skovsmose (1997) who emphasized the concept of foreground – besides the notion of background. Where the background means what children bring to the classroom, foreground is to be understood as "[T]he set of opportunities that the learner's social context makes accessible to the learner to perceive as his or her possibilities for the future" (Vithal & Skovsmose, 1997, p. 147). Skovsmose (2005) also emphases the political and cultural situation as an important aspect of the foreground, since they provide – or blocks – the opportunities for the learner. It makes the political nature of the learning process explicit because it has to do with the student's possibilities in future life, not the objective possibilities as formulated by an external institution but the possibilities as the student perceives them.

The learner brings a 'background of knowledge' into the learning situation: he or she already appropriated knowledge, which is relevant for the issues or the problems presented in the school setting. For instance, each child has a mental map of the environment, which will allow to cover the distance between school and home cultures in a rather efficient and safe way. At the same time, the child has a 'foreground of knowledge', which is the set of extensions of the knowledge that is appropriated together with the competencies to enable further learning, like understanding the school culture, management of problem solving techniques regardless of concrete contexts, and so on are examples of this. The child is actively learning in a classroom while making use of this 'mental setup'.

LEARNING AND CULTURE IN THE MATHEMATICS CLASSROOM

Every couple of years the OECD assesses the quality of education throughout the world. These researches yield regular reports (the PISA reports), which give an overview of the success and failure ratio of children in and through schooling in mathematics education. A recurring point in these reports is that (lower and higher) middle class pupils have a high success rate, whereas lower social classes and minority groups are showing poor results (OECD, 2010).

Our hypothesis reads as follows: the common mathematics curriculum and teaching procedures start from the point of view that mathematicians (belonging to the group of so-called Academic Mathematics) define the school program in basic lines. The understanding seems to be that mathematics is what Academic Mathematics says it is. Obviously the immense sophistication of this type of knowledge and its proven worth in scientific and technological research feeds this status. The pupils then try to master that, equipped as they are with their particular sets of background of knowledge and foreground of knowledge. The systematic and clearly not decreasing failure in school mathematics of the groups mentioned, can hence only be blamed on the academic mathematics group who set out the rules of the curriculum.

When we take the stand that learning is in actual fact always situated learning and that the learner brings his or her background of knowledge and foreground of knowledge into the learning situation, we can draw the conclusion that the fact of disregarding the background of knowledge and the foreground of knowledge in the learners can explain why their performance is consistently poor. At the very least we can explain why more schooling does not automatically yield better results in mathematical education, especially for particular groups (as is shown in the PISA reports). But in order to do that, we have to take one more step.

Learners have a background of knowledge and a foreground of knowledge. But what about mathematicians, and their product of thought, i.e., Academic Mathematics? We propose the hypothesis that mathematical knowledge in Academic Mathematics has implicit categories, worldview notions, intuitions, and the conceptual frame, which can be argued to be compatible with or translatable into that of a particular group of learners to a larger or smaller extent. Concretely, we suggest to investigate whether the middle class western subject's background of knowledge and foreground of knowledge is more easily translatable, accessible, or more closely overlapping with the worldview and categorization of Academic Mathematics than is the case with North American Indians, or lower class local groups and immigrant groups in Western Europe.

What we do by forwarding this hypothesis is not denying the tremendous worth of Academic Mathematics as a way of thinking and as a formidable tool for science and technology. Neither do we fall prey to a simplistic relativism, denying the high level of sophistication of this discipline. Instead, we claim that Western Academic Mathematics, like any human product, has its roots and that in learning Academic Mathematics these roots may show their relevance.

The structure of the Indo-European languages distinguishes between verb and noun forms. With this distinction corresponds a differentiation between things/states and operations/processes in the conceptualization of the perceived reality. Intuitively, mathematical thinking sophisticates these deep structural linguistic and cultural differentiations (Pinxten, van Dooren, & Harvey, 1983). Hence, the emphasis on geometric figures (with a thing-character) and their constitutive forms, on sets and their elements, on operations (of multiplication and so on) performed on entities (a number, a series, etc.). The point we want to make is that formal thinking elaborates the intuitive world view which is given in language and in folk knowledge (Atran, 1990). When investigating other cultural traditions we learn that Athapaskan and Cherokee languages, like Classic Chinese are 'verb languages'. That is to say, the noun category is inexistent or at least not substantial, corresponding to a view on reality as basically a world of events (Whitehead, 1906).

Again, regardless of the great achievements of Academic Mathematics, it is our conviction that it will be important to take these preschool differences into account for mathematics education. The dropout rates (cf. the PISA reports; OECD, 2010) might well be better understood in the light of these differences in preschool competences, to be found in the learner's background of knowledge. Following that line of reasoning, we must then conclude that it is likely that neglecting the background of knowledge of the child will yield lack of insights or more difficulties with the Academic Mathematics – inspired mathematics curriculum and learning procedures. Alternatively, we advocate to systematically involve the child's background of knowledge and foreground of knowledge in the educational process. By necessity this means that mathematics education (and hence also introduction to Academic Mathematics concepts and theories) will have to take into account the different backgrounds of knowledge and foregrounds of knowledge of varying cultural traditions.

FINAL REMARKS

Learners always bring their background knowledge into the learning process. We proposed that Academic Mathematics is culturally embedded, that is to say, Academic Mathematics has its own (implicit) categories, worldviews and applications. The challenging question remains how to close and thus to overcome the gap between on the one hand the diverse Communities of the learners and on the other hand the communities of the learning institution (school cultures, curriculum, teacher, …). In order for teachers to deal with the diversity of backgrounds of knowledge, they should have knowledge of these cultural backgrounds, traditions, languages, practices and mathematical practices the learner (can) bring into the learning context. Teachers should have an anthropological perspective on the learning processes, on the school culture, and on the diverse cultures the learners bring to school. That is why we propose to use anthropological studies in the learning process in general.

As an alternative to the monolithic approach to mathematics we can now pave the way for our option for multimathemacy. Multimathemacy is an educational perspective that invites the teaching of different cultural insights on counting, proportional thinking, mapping or spatial organization in preschool and out of school knowledge and this view offers bridges between academic mathematics and cultural knowledge traditions for schooling.

REFERENCES

Alrø, H., Ravn, O., & Valero, P. (Eds.) (2010). *Critical mathematics education: Past, present, and future. Festschrift for Ole Skovsmose*. Rotterdam: Sense Publishers.

Atran, S. (1990). *Cognitive foundations of natural history: Towards an anthropology of science*. Cambridge: Cambridge University Press.

Bakhtin, M. (1986). *Speech genres & other late essays* (C. Emerson & M. Holquist (Eds.). Austin: University of Texas Press.

Bruner, E. M. (1984). Introduction: The opening up of anthropology. In S. Plattner & E. M. Bruner (Eds.), *Text, play, and story: The construction and reconstruction of self and society—1983 proceedings of the American ethnological society* (pp. 1-16). Princeton, NJ: American Ethnological Society.Cole, M. (1996). *Cultural psychology: A once and future discipline*. Cambridge: Harvard University Press.

Howard, P., Cooke, S., Lowe, K., & Perry, B. (2011). Enhancing quality and equity in mathematics education for Australian indigenous students. In B. Atweh, M. Graven, W. Secada, & P. Valero (Eds.), *Mapping equity and quality in mathematics education* (pp. 365-378). Dordrecht: Springer.

Lave, J. (1988). *Cognition in practice. Mind, mathematics, and culture in everyday life*. Cambridge: Cambridge University Press.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

OECD (2005). *PISA 2003 technical report*. Paris: OECD Publishing.

OECD (2010). *Educational research and innovation. Educating teachers for diversity. Meeting the challenge.* Paris: OECD Publishing.

Piaget, J. (Ed.) (1972). *Structuralisme et épistémologie génétique.* Paris: Pléiade.

Pinxten, R., van Dooren, I., & Harvey, F. (1983). *Anthropology of space.* Philadelphia: University of Pennsylvania Press.

Pinxten, R., & François, K. (2011). Politics in an Indian canyon. Some thoughts on the implications of ethnomathematics. *Educational Studies in Mathematics. 78*(2), 261 – 273.

Skovsmose, O. (2005). *Travelling through education. Uncertainty, mathematics, responsibility*. Rotterdam: Sense Publisher.

Skovsmose, O., & Borba, M. (2004). Research methodology and critical mathematics education. In P. Valero, & R. Zevenbergen (Eds.), *Researching the socio-political dimensions of mathematics education. Issues of power in theory and methodology*. Mathematics Education Library (vol. 35, pp. 207-226). Dordrecht: Springer.

Vithal, R., & Skovsmose, O. (1997). The end of innocence: A critique of ethnomathematics. *Educational Studies in Mathematics, 34*(2), 131-157.

Vygotsky, L. S. (1934/1962). *Thought and language* (Myshlenie I rech', Trad.). Cambridge MA: MIT Press. [Original work in Russian, in 1934].

Whitehead, A. N. (1906). On mathematical concepts of the material world. In *Philosophical transactions of the royal society of London, Series A, Mathematical and physical sciences*. Volume 205 (pp. 465-525). London: Royal Society by Dulan.

Zhao, N., Valcke, M., Desoete, A., Zhu, C., Sang, G., Verhaeghe, J. P. (2012 in press). A holistic model to infer mathematics performance: the interrelated impact of student, family and school context variables. *Scandinavian Journal of Educational Research*, http://hdl.handle.net/1854/LU-2105450, DOI 10.1080/00313831.2012.696210