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SOCIOMATHEMATICS:
A SUBJECT FIELD AND A RESEARCH FIELD

Tine Wedege

School of Teacher Education, Malmö University, Sweden

Abstract. *Complexity is a characteristic of problem fields related to mathematics education and, in any study; the researcher has to focus on one of the problems without ignoring the others. Diversity (gender, ethnicity, social class etc.) in the subject area calls for multi- and inter-disciplinary studies and for different research methodologies. The concept of sociomathematics is developed and suggested as a name for a subject field where people, mathematics and society are combined, and for the research field where the societal context of knowing, learning and teaching mathematics is taken seriously into account. This is done through a critical dialogue with ethnomathematics.*

COMPLEXITY IN MATHEMATICS EDUCATION

Le sens du problème est le moteur du progrès scientifique (Bachelard, 1927).

Research is always a response to a problem. The epistemological assumption that the sense of the problem is the motor of scientific progress is a frame of reference for this paper. Thus, understanding, selection, interpretation and formulation of problems and research questions are seen as vital activities in the researchers' practices. Complexity is a characteristic of mathematics education research and none of the problems in or related to teaching, learning and knowing mathematics can properly be isolated from the others. In any educational study, the researcher has to focus on one of the problems without ignoring the others. Diversity (gender, ethnicity, social class etc.) in the subject area calls for multi- and inter-disciplinary studies and for different research methodologies. However, the focus and the methodology of any study are determined by its purpose, theory and research questions. For example Evans and Tsatsaroni (2008) have argued that research into gender within a social justice agenda requires both quantitative and qualitative methods. When the problem is formulated as a research question and the method and the sampling strategy are to be decided, the researcher has to choose among a series of factors and dimensions to reduce complexity. The societal context is one of the aspects to decide upon. In some studies, *society* is a dimension *in the foreground*: the study is designed to investigate society and mathematics education – meaning that the societal context is addressed in the research question and suitable theories and methods are chosen. In other studies, *society* is *in the background*: societal factors are just independent variables among others. *No society* in the study means that information about the societal context is not available in the data.

In a study of students' motives (motivation, reasons, rationale) for learning or not learning mathematics, society can be in the background or ignored (Hannula, 2004; Wæge, 2007) or in the foreground (Alrø et al., 2009; Mellin-Olsen, 1987; Wedege & Evans, 2006). The notion of *landscapes of learning* is introduced by Alrø, Skovsmose and Valero (2009) as a tool to capture and structure some of the complexity and to guide their study – with society in the foreground – of students' motives for learning mathematics in the multicultural mathematics classroom. Landscapes of learning is a notion with a double meaning which brings together a research perspective and a research field:

> First, it represents an interpretation of (mathematics) education as a complex network of social practice that is constituted by different interrelated dimensions. Second, it makes possible to identify specific – but interdependent – dimensions of an empirical field to do research (Alrø et al., 2009, p. 330).

Based on recent research, the authors have selected nine dimensions as relevant aspects to be considered for at better understanding of the social complexity of classrooms. Among theses dimensions are for example "students' foregrounds as an experienced socio-political reality", "teachers' perspectives, opinions and priorities of teaching", "the (mathematical) content for learning", and "public discourses about immigrants, schooling and multiculturalism".

Complexity is highlighted through the notion of landscapes of learning with students' motives for learning mathematics as an example of a subject field for mathematics education research. The problem field of the mathematics classroom is opened to the societal context and simultaneously restricted by the lens of the landscapes of learning, which reflects the problematique of Critical Mathematics Education. Some research questions are legitimized and possible to formulate from this perspective, other questions are not (Wedege, 2006). In this paper, I develop a conceptual framework around the concept of *sociomathematics*, which has a double meaning like the notion of learning landscapes. First, sociomathematics is a field to be researched (a subject field) where problems are formulated bringing people, mathematics and society together. Second, sociomathematics is a research field where the societal context of mathematics education is seriously into account, e.g. scientific studies with society in the foreground.

THE TERM "SOCIOMATHEMATICS"

I found my inspiration for the term "sociomathematics" in *sociolinguistics* i.e. relationships between language and society constituted as a scientific field within linguistics. However, sociomathematics is a field within mathematics education research where people’s relationships with mathematics in society are studied, not a sub-discipline of mathematics.

Previously, the substantive “sociomathematics” has been used by Zaslavsky (1973) in a meaning similar to “ethnomathematics”. She explains *sociomathematics* of Africa as ”the applications of mathematics in the lives of African people, and, conversely, the influence that African institutions had upon their evolution of their mathematics” (p. 7). In mathematics education research, the adjective “sociomathematical” is used at the level of the social context of the classroom. Cobb and his colleagues developed the concept *sociomathematical norms* in an interpretive framework for analyzing mathematical activity at classroom level from a social perspective (classroom social norms, sociomathematical norms and classroom mathematical practices) and from a psychological perspective (beliefs about roles and mathematical activity in school, mathematical beliefs and values, and mathematical conceptions and activity) (Cobb & Yackel, 1996). In this framework, the social category of sociomathematical norms is combined with the psychological category of mathematics beliefs and values. In my terminology, studies of sociomathematical norms in a classroom would be regarded as sociomathematics only if the students’ relationships with mathematics *in* society are explicitly on the agenda; for example related to the students’ gender, ethnicity or class.

FROM ETHNOMATHEMATICS TO SOCIOMATHEMATICS

From my research on adult mathematics education, I realised that a concept of the kind developed in this paper was needed. The concept of ethnomathematics has been a very important notion in my studies of workers’ mathematics in the workplace (Wedege, 2000). In both meanings of the term as defined by Gerdes (1996): ethno-mathematics as a subject field (a field studied in mathematics education research) in contrast to “school mathematics” and as a research field, ethnomathematics reflects an acceptance and a consciousness of the existence of many forms of mathematics, each particular in its own way to a certain (sub)culture. Ethnomathematicians argue that the techniques and truths of mathematics are a cultural product and stress that all people – every culture and subculture – develop their own particular forms of mathematics. D’Ambrosio (1985) contrasted *academic mathematics* (the mathematics taught and learned in schools) with *ethnomathematics*, which he describes as the mathematics “which is practised among identifiable cultural groups such as national-tribal societies, labour groups, children of a certain age bracket, professional classes, an so on” (p. 45). Ethnomathematicians emphasise and analyse the influences of socio-cultural factors on the teaching, learning and development of mathematics (Gerdes, 1996).

I have argued that ethnomathematics paved the way for researching workers’ mathematics in the workplace. However, in the Danish vocational context, we have never used the word “ethnomathematics” instead we talk about “workplace mathematics” or “everyday mathematics”. In many languages and situations, the prefix “ethno” has connotations with reference to biological characteristics, colour of skin etc. At the Second International Congress on Ethnomathematics, 2002, Skovsmose referred to his strong reservations about the use of the word “ethnomathematics”. However, his reservation is not to do with the meaning of “ethno” in the literature of ethnomathematics where, according to D’Ambrosio, it simply refers to “environment”, e.g. culture and society: mathematics is acted out in many different ways in different cultures and by different groups. What is emphasised in ethnomathematics are the connections between culture and mathematics: Mathematics is always culturally embedded. Thus “engineering mathematics” and “mathematics in semi-skilled job functions” also represent different branches of ethnomathematics (Skovsmose, 2002).

I found that “sociomathematics” could be an answer to this terminological problem. However, sociomathematics is not just a translation of the word ethnomathematics into a “cleaner” word. It is also a notion that makes explicit the power relations in mathematics education. On the basis of previous studies of people and mathematics in society – others’ and my own – I have given a preliminary definition of socio-mathematics as an analytical concept addressing relationships between people, mathematics and society, which encompasses the studies of for example numeracy, ethnomathematics and workplace mathematics in a single term (Wedege, 2003). In his discussion of socio-political functions of mathematics education, Skovsmose (2006) has found that the conceptual suggestion of sociomathematics “might help to establish further relationships between the ethnomathematical programme, and those very many studies which share a number of the same concerns, but which might find it awkward to operate with the notion of ethnomathematics” (p. 275).

THE CONCEPT OF SOCIOMATHEMATICS

By *sociomathematics* I mean:

- a subject field combining mathematics, people and society,
- a research field where problems concerning the relationships between people, mathematics and society are identified, formulated and studied.

As a subject field, sociomathematics is defined by a specific perspective on the subject area of people, mathematics and society – as it may be found for example in notions of ethnomathematics, folk mathematics, mathematical literacy, adult numeracy and mathematics-containing qualifications (see figure 1). As a research field sociomathematics reflects an acceptance and a consciousness of the influence of the societal context in the knowing, learning and teaching of mathematics, i.e. society is in the foreground when research is designed. *Sociomathematical problems* concern:

(1) people's relationships with mathematics (education) *in* society and vice versa.

People's relationship might be seen as cognitive, affective or social according to the given perspective of a specific study. A problem to be studied could be: What does it mean to know mathematics in society? The issue is the relationship between people and mathematics in society but to investigate problems in this field one has to involve two other problem complexes:

(2) functions of mathematics (education) in society and vice versa, and

(3) people learning, knowing and teaching *in* society.

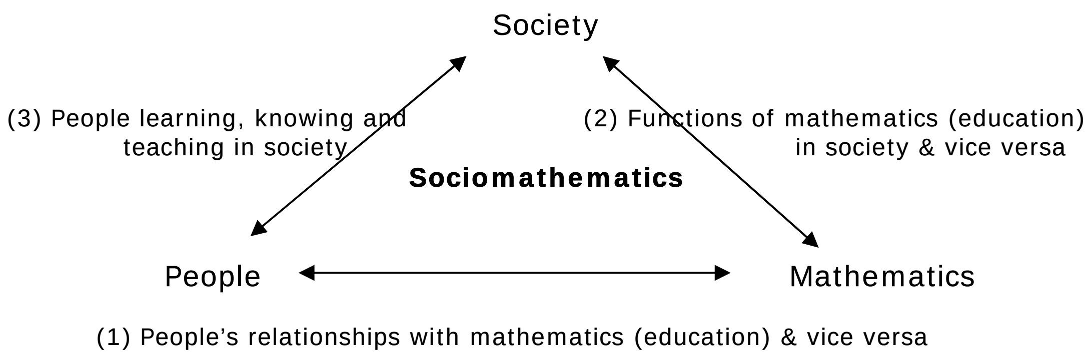

Figure 1. Sociomathematics as a subject field (Wedege, 2003, p. 2).

In Skovmose's studies of students' learning obstacles in mathematics, one finds an example of a *sociomathematical concept* construction. He does not find the cultural background of the students sufficient to account for the situation but also involves their *foreground*, i.e. the opportunities provided by the social, political and cultural situation: "When a society has stolen away the future of some group of children, then it has also stolen the incitements of learning" (Skovsmose, 2005, p. 6). The issue of *mathematisation* presented by Jablonka and Gellert (2007) as describing and analysing the social, economical and political processes in which relationships between participants in society become increasingly formal, is an example of a *sociomathematical problem*. An example of a *sociomathematical study* is for example found in my inquiry of adults learning mathematics (Wedege, 1999). I go beyond the local situation given by Lave's socio-psychological concept of community of practice and involve Bourdieu's sociological concept about *habitus* meaning a system of dispositions which allow the individual to act, think and orient him or herself in the social world:

> (…) the habitus of a girl born in 1922 in a provincial town as a saddler's daughter, of a pupil in a school where arithmetic and mathematics were two different subjects at a time where it was "OK for a girl not to know mathematics", and the habitus of a wife and mother staying home with her two daughters is a basis of actions (and non-actions) and

> perceptions. Habitus undergoes transformations but durability is the main characteristics (Wedege, 1999, p. 222)

People's habitus is incorporated in the life they have lived up to the present and consists of systems of durable, transposable dispositions as principles of generating and structuring practices and representations (Bourdieu, 1980).

According to the definition, the mathematics shared by a cultural subgroup of only two persons could be regarded as "ethnomathematics". I would not call a phenomenon like this "sociomathematics". However, the critical approach to ethnomathematics defined by Gelsa Knijnik (1998) is a clear example of a perspective that could be termed "sociomathematical". Her study of landless peasants' mathematics is not just about people's competences in a well-defined cultural context but about a larger political context, where power relations are made visible. In a sociomathematical study, societal rights and demands (from the labour market, educational system, democracy) are made explicit as well as consequences for people belonging to different social classes. Gellert (2008) has shown what difference a sociomathematical perspective can lead to in interpretations and understanding of data from a mathematics classroom. He has chosen a short transcript of sixthgraders collaborative problem solving. From a structuralist perspective, classroom practices are regarded as social representations that are more or less accessible to students, depending on their social backgrounds, and this is made visible in his analysis.

TO KNOW MATHEMATICS IN SOCIETY

Today it is scientifically legitimate to ask questions concerning people's everyday mathematics and about the power relations involved in mathematics education. In other words, it is legitimate to ask "What does it mean to know mathematics in society?" In all three dimensions of the triangle (figure 1), power is a central sociomathematical issue. In his book "The Politics of Mathematics Education", Mellin-Olsen (1987) stated that it is a political question whether folk mathematics is recognized as mathematics or not. He presents the book as a result of a twenty year long search "to find out why so many intelligent pupils do not learn mathematics whereas, at the same time, it is easy to discover mathematics in their out-of-school activities" (p. xiii). FitzSimons (2002) states that the distribution of knowledge in society defines the distribution of power and, in this context, people's everyday competences do not count as mathematics. In policy documents in educational systems, in teachers' practices, and in research in the teaching and learning of mathematics, the power of mathematics and mathematics education is clearly assumed. However, it is not clear what is really meant by the terms "power" and "mathematics", particularly when it is being used differently by the multiple actors involved in giving meaning to the practices of the teaching and learning of mathematics in society (Valero & Wedege, 2009).

Definitions of mathematical literacy and related studies are concerned with the relationships between people, mathematics and society, and any construction of a concept of mathematical literacy appears as an answer to the question ”What does it mean to know mathematics in society?” Thus, mathematical literacy – for example in PISA – ought to be a sociomathematical concept. The latest definition from the theoretical framework of the survey sounds as follows:

> *Mathematical literacy* is an individual’s capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments and to use and engage with mathematics in ways that meet the needs of that individual’s life as a constructive, concerned and reflective citizen. (OECD, 2006, p. 72)

According to the framework, the PISA mathematical literacy “deals with the extent to which 15-year-old students can be regarded as informed, reflective citizens and intelligent consumers” (Ibid). According to this definition, the approach of PISA, which pretends to assess mathematical literacy of students near the end of compulsory education, should start with the needs of the individuals in society. However, the concrete construction of the eight mathematical competencies composing mathematical literacy (thinking and reasoning; argumentation; communication; etc.) is general starting with mathematics and ending up with mathematics. In the test items the so-called real world situations are only a means for re-contextualising mathematical concepts and in the end “it is not the situations themselves which are of interest, but only their mathematical descriptions” (Jablonka, 2003, p. 81). Thus, I claim that in spite of the declared purpose of PISA this survey is not sociomathematical. However, one may find that society is in the background with social class as an independent variable.

PERSPECTIVES

The problem behind the development of the conceptual framework of sociomathematics is located in term and content of ethnomathematics. In this paper, sociomathematics is defined with a double meaning: As a subject field where people, mathematics and society are combined, and as a research field where people’s cognitive, affective and social relationship with mathematics in society is investigated. As mentioned above, Gerdes (1996) has also identified ethnomathematics as a subject field and a research field. In addition, he argues that the ethnomathematical paradigm includes principles for educational practice. For example, ethnomathematicians look for cultural elements and activities that may serve as a starting point for doing and elaborating mathematics in the classroom. Within science education research, a notion of *socio-scientific issue* has been developed and Ekborg, Ideland & Malmberg (2009) have shown that a way to increase Swedish students’ interest in school science is to bring in a humanistic perspective, i.e. issues with a basis in science which are important for society and are dealing with moral and ethics. In Sweden, a similar experiment has been made in bringing up socio-mathematical issues in compulsory mathematics for social science students in upper secondary school (Course A). This course is on the borderline to more advanced mathematics studies and it covers elementary mathematical content such as arithmetic, geometry, algebra, statistics and basic-level functions. Normally, the problem is that the mathematical content is not connected to other subjects in the social sciences programme and the students find the mathematical activities meaningless. Integrating mathematics with social science offered the possibility for students to exercise a degree of personal agency and many students expressed their experiences of meaning in this experimental course (Andersson & Valero, In press).

Recently Yasukawa (2007) argued that the UN declared decade of education for sustainable development (2005-2014) presents an opportune moment for mathematics education educators and researchers to “reflect about the effectiveness that mathematics education has had in creating citizens for a sustainable future” (p. 7). Introducing the term “socio-mathematical issues” in mathematics education corresponding to “socio-scientific issues” in science education could be a possible answer to this challenge. At the same time, the conceptual framework of sociomathematics could be extended to include principles for bringing socio-mathematical issues into educational practice.

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