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Needs versus Demands:

Some ideas on what it means to know mathematics in society

Why do we have to learn the division of two fractions? This is a simple question from students, nevertheless causing trouble to mathematics teachers all over the world. But, do they really have to be prepared for answering specific questions like this about any mathematical concept, formula and method? As an educator, I find it important that future mathematics teachers know about the justification problem and are prepared to discuss the global problem: Why teach – and learn – mathematics at all. I see this as a prerequisite for going into a dialogue with pupils about local problems like: Why learn to divide fractions in lower secondary school in Sweden? Any answer to the global problem providing reasons for teaching mathematics may be economic, cultural, technological, political, ideological, historical etc. (Jensen, Niss, Wedege, 1998). Thus, any answer is value based and, furthermore, any reason given is based on an idea of the content in mathematics education. It is not possible to reflect upon the question why without engaging with the question what and vice versa. “Why” is tangled with “what” in mathematics education and, in any discussion about reasons for teaching and learning mathematics, the issue of content is present, explicitly or implicitly. Thus, the philosophical issue behind any justification debate in mathematics education is about the nature of mathematics and on knowing mathematics. That is the reason why the teacher students in Malmö read Paul Ernest’s article “Relevance versus Utility: Some ideas on what it means to know mathematics” (Ernest, 2004).

In this chapter, after an introduction to the justification problem, I will illustrate the complexity of this problem in mathematics education by presenting and discussing the dualism between utility and relevance, as Ernest is seeing it in a social context, and subsequently the dualism between demands and needs from a sociomathematical point of view. From the discussion of what does it mean to know mathematics, I move to some ideas of what it means to know mathematics in society.

Justification in mathematics education

The term “justification problem” (Danish: *begrundelsesproblemet*) was introduced by Skovsmose in 1980 to describe difficulties faced by a group of teacher students when they had to legitimate mathematics at a parents’ meeting, according to Johansen (2006). In an international context, Niss (1996) has studied the justification and provided an analysis of its nature in the handbook chapter “Goals of mathematics teaching”. Previously, he had pointed to the need of a terminological distinction between two kinds of goals: The term “purposes” includes the motives and reasons which justify the existence of mathematics education. While the term “objectives” includes the specific qualifications (today: competencies) which mathematics education is aiming at (Niss, 1981). The *justification problem* deals with the purposes, the reasons, motives and arguments, for providing mathematics education to a given category of students. Answers

to the question “why mathematics education?” are in focus and they have to “rely on and reflect perceptions of the role of mathematics in society, of the philosophy of mathematics, the socioeconomic and cultural structure, conditions and environment in society, ideological and political ideals, and thus vary with place and time” (Niss, 1994, p. 373).

The purposes – motives and reasons – for mathematics education are seldom on the agenda in the public debate. When politicians and educators argue explicitly for the need of teaching and studying mathematics in society it can be seen a sign of a crisis in the school subject. From the end of the 1980’s, a trend of decreasing enrolment in education involving mathematics and physics was observed, internationally. This was the background for a conference on justification problems held in Denmark 1997 (Jensen, Niss, Wedege, 1998). As one of the speakers at this conference, Ernest described the justification problem like this:

The justification problem in mathematics education concerns the following questions. Why teach mathematics? What is the philosophy of mathematics education in terms of the purposes, goals, justifications, and reasons for teaching mathematics? How can current plans and practices be justified? What might be rationale for reformed, future or possible approaches for mathematics teaching? What should be the reason for teaching mathematics, if it is taught at all? These questions begin to indicate the scope of the justification problem, (...) (Ernest, 1998, p. 33).

It is obvious from both definitions that answers to the question “Why mathematics education” rely on and reflect conceptions of the role of mathematics in society and positions in philosophy of mathematics education. In his further analysis, Niss (1996) takes an educational, societal and political glance at the problem by grouping the (official) reasons for mathematics education in three general types: (1) Contributing to the technological and socio-economic development of society at large; (2) Contributing to society’s political, ideological and cultural maintenance and development; (3) “Providing individuals with prerequisites which may help them to cope with life in the various spheres in which they live: education or occupation; private life; social life; life as a citizen” (Niss, 1996, p. 13).

In a debate on reasons and motives for mathematics education, there are two main types of purposes at two agent levels: one referring to the needs of society (general) and one to the needs of individuals (subjective) and doing this explicitly or implicitly. Furthermore, the focus can be global concerning mathematics education as such or local dealing with the question why mathematics education for this category of students in this specific educational programme. Without setting this up explicitly the dialogue is complicated. In the conference book mentioned above, a justification matrix with two dimensions is offered for reflections and analyses of reasons for teaching and studying mathematics (see table 1).

Table 1. Justification matrix (after Jensen, Niss & Wedege, 1998, p. 10)

Agent level Extent	General ("system") reasons ¹	Subjective ("individual") reasons
Global reasons	general reasons for the very existence of studies involving mathematics (1)	subjective reasons for engaging in studies involving mathematics at all (2)
Local reasons	general reasons for the specific design, organisation, and implementation of specific programmes (3)	subjective reasons for engaging in particular aspects and activities of a programme in particular ways (4)

In the matrix in table 1, four different points of view are possible. By *general* reasons we mean reasons that reside on either a societal or an institutional level, determined from "outside" or by the "system". From a general viewpoint, the focus can be on the overall reasons for the very presence of mathematics in a variety of educational programmes (1). Such global reasons may be economic, cultural, technological, political, ideological, historical etc. The focus can also be on the local reasons for the design, organization, and implementation of programmes in specific educational sectors or institutions (3). By *subjective* reasons we mean reasons that reside on the level of the individual. From a subjective viewpoint, the issues are about the (global) reasons that make a given individual decide – at all – to involve in mathematical studies (2), and about the (local) reasons for an individual to engage in specific aspects of these studies (4) (Jensen, Niss & Wedege, 1998).

When analysing the goals (purposes and objectives) of mathematics education from the general point of view as a reflection of the needs of a given society there are some methodological difficulties. The researcher faces the principal and practical problem of detecting and identifying (and documenting) the actual impact of mathematics education of social needs (see Niss, 1981). Nevertheless, scientists like Kilpatrick et al. (2001, p. xiii) and Bishop (1999, p. 1) argue for societies' "mounting need for proficiency in mathematics" and demands of "much greater mathematical knowledge" respectively and doing this without any references to empirical evidence. Skovsmose (2006) finds that much research in mathematics education is based on the assumption that mathematics education contains an intrinsic value. He refers to an essentialism assuming that there is a positive value in mathematics education guaranteed by the very fact that this education addresses mathematics. Skovsmose points to this assumption as ensuring that "mathematics educators can operate as "ambassadors" of mathematics, with the certainty that they are acting on behalf of a good cause" (p. 276). In his justification article mentioned above, Ernest (1998) discusses myths about mathematics in society; for example that "mathematics is very useful, and more maths skills are needed among the general populace in industrialized societies". He states, what he sees as his most controversial set of claims:

(...) the utility of mathematics in the modern world is greatly overestimated, and the utilitarian argument provides a poor justification for the universal teaching of the subject throughout the years of compulsory schooling (Ernest, 1998, p. 38).

As asserted above, it is appropriate to make a terminological distinction in mathematics education goals between the *purposes* (motives, reasons for teaching and learning mathematics) and the *objectives* (mathematical capability, proficiency, knowledge, competence, skills, etc. as aims in the teaching and learning of mathematics). From this follows that one can see why (reason) and what (content) in mathematics education as two sides of the same coin.

Objectives: Relevance versus utility

Stated in general terms, the objective of mathematics education is that students know mathematics. But, what does it mean – or might it mean – to know mathematics? This is the central issue in Ernest (2004) where he uses the term “mathematical capability” – and not “mathematical knowledge – to present and discuss his ideas in the social context of mathematics teaching and its individual outcomes. In this discussion, Ernest puts aside differences between societies and cultures and he uses a post-industrial western democracy like Sweden as his reference point. The students in his reflections are 16-18 years of age and about the end of compulsory schooling. He is doing this with a focus on general and common issues without looking at different individual needs. As any discussion about objectives this one is inevitably related to the purposes of mathematics education and – with the generalisations mentioned – Ernest puts himself at the global level combined with the subjective agent level: individual reasons for engaging in studies involving mathematics at all (2 in the justification matrix, table 1).

Ernest claims that human capabilities and capacities are always for certain activities, purposes and functions. But, in order not to fall into a utilitarian trap, he draws a distinction between “utility” and “relevance”. He finds that both qualities are value-laden terms used to denote what is the speaker deems apposite relative to a given context:

Utility means “a narrowly conceived usefulness that can be demonstrated immediately or in the short term, without consideration of broader contexts or longer term goals” (p. 314). One of the outcomes of utilitarian education is that mathematics is communicated as narrowly technical isolated from issues of value and social concern. *Relevance* is seen as a ternary relation between three things (R, P, G). R is a situation, an activity or an object to which relevance is ascribed. P is a person or group of people who ascribes relevance to R. G is a goal which embodies the values of P in this instance. Thus object R is relevant when considered so by the person P in achieving the goal G. For example school mathematics (the object R) is said to be relevant “by many politicians and educational leaders (the group P) with the aim (the goal G) of increasing the mathematical competence and technologically-related employment skills of the population (which is assumed to increase economic output and national prosperity) (p. 315). In his clarification of what relevance means in mathematics education, the term used by Ernest is “goals”. Even though this is not explicit, it seems that the term, in the context of the relevance discussion, encompasses both meanings (purpose and objective).

In order to answer the opening question (what it means to know mathematics), Ernest distinguishes a series of different objectives for teaching and learning mathematics based on an analysis that he has made of five ideological groupings in the mathematics curriculum debate in Britain (industrial trainer, technological pragmatist, old humanist, progressive educator, public educator) (Ernest, 1991). Corresponding to these objectives, which Ernest sees as complementary, he formulates five capabilities to be developed by the learners and added a sixth capacity: the appreciation of mathematics in itself as an element of culture (see table 2).

Table 2. Different teaching and learning objectives and capabilities (Ernest, 2004 p. 317).

Objective	Associated mathematical capabilities
1. Utilitarian knowledge	To be able to demonstrate useful mathematical and numeracy skills adequate for successful general employment and functioning in society
2. Practical, work-related knowledge	To be able to solve practical problems with mathematics, especially industry and work centered problems
3. Advanced specialist knowledge	To have an understanding and capabilities in advanced mathematics, with specialist knowledge beyond standard school mathematics (...)
4. Appreciation of mathematics	To have an appreciation of mathematics as a discipline including its structure, subspecialisms, the history of mathematics and the role of mathematics in culture and society in general
5. Mathematical confidence	To be confident in one's personal knowledge of mathematics, to be able to see mathematical connections and solve mathematical problems, and to be able to acquire new knowledge and skills when needed
6. Social empowerment through mathematics	To be empowered through knowledge of mathematics as a highly numerate critical citizen in society, able to use this knowledge in social and political realms of activity

Internationally, the logic of competence has taken over in the educational discourse in general and in the discourse in mathematics education specifically, since the mid 1990's (Wedge, 2003b). Ernest does not use the term "competence", but in his construction of mathematical capabilities and capacities, the main ideas of competence as objective in educations are incorporated.

According to Ernest (2004), the learning objectives in table 2 are not mutually exclusive and they are not necessarily desirable or relevant for all learners. I see the six objectives formulated as capabilities or capacities forming together a "mathematical competence" (a construction of what it might mean to be mathematical competent) as an answer to the question what does it mean to know mathematics. The objectives "utilitarian knowledge" (1) and "practical, work-related knowledge" (2) are both

presented as the ability to do something (knowing how), and they are supposed to be useful for the students as future workers. “Advanced specialist knowledge” (3) is supposed to be useful for some and relevant to others (3) and “appreciation of mathematics” (4) is supposed to be relevant to all students (knowing that). The two last objectives “mathematical confidence” (5) and “social empowerment through mathematics” (6) represent affective and social dimensions of being mathematical competent. Thus, Ernest’s construction of mathematical competence in a social context encompasses cognitive elements (skills and knowledge), affective elements (confidence) and social elements (empowerment) as well as their dynamic interplay.

To know mathematics in society

The context for Ernest’s construction of mathematical knowledge – as capabilities and capacities – is social. Concepts of people’s social competences like ethnomathematics and folk mathematics, as well as concepts of adult numeracy, mathematical literacy and of mathemacy, have expanded the problem field of mathematics education research (Gerdes, 1996; Jablonka, 2003; Mellin-Olsen, 1987; Skovsmose, 1994; Wedege, 1999). 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 the studies of for example ethnomathematics and adult numeracy, a social approach is common and a critical perspective can be opened up when studies concern the functions of mathematics education in society and in people’s lives.

By definition, any notion of mathematical literacy or numeracy contains the societal dimensions of mathematics, technology and culture. The definitions of mathematical literacy and of numeracy and the related studies are concerned with the relationships between people, mathematics and society. On the basis of previous studies, I have given a preliminary definition of an analytical concept, which encompasses the studies of numeracy and mathematical literacy and related concepts of knowing mathematics in society in a single term. By *sociomathematics*², I mean

- a problem field concerning the relationships between people, mathematics and society, and
- a subject field combining mathematics, people and society – as we may find it for example in ethnomathematics, folk mathematics or adult numeracy (Wedege, 2003a, p. 2).

In my terminology, sociomathematics is the name of a subject field (a field of study) and a specific problem field just like ethnomathematics (see Gerdes, 1996) (see figure 1).

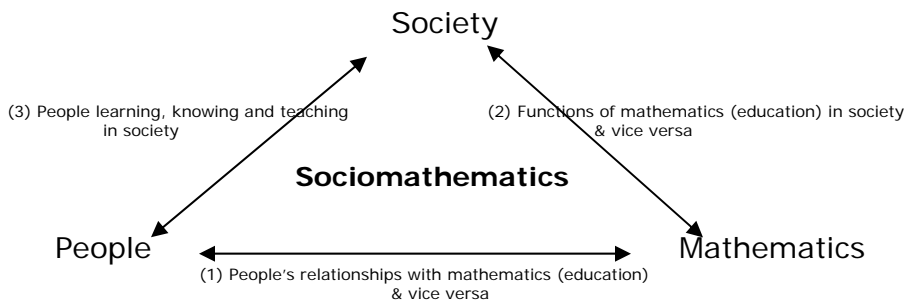


Figure 1. Sociomathematics as a subject field (Wedega, 2003a, p. 2).

Sociomathematical problems concern (1) people’s relationships with mathematics (education) *in* society and vice versa. The relationship between humans and mathematics can be seen as cognitive, affective or social according to the given view point of a specific study. This relationship is the key issue, but to investigate this problem one has to study two other problems: (2) the functions of mathematics (education) in society and vice versa, and (3) people learning, knowing and teaching *in* society. Power is a central sociomathematical issue related to all three dimensions. In his book “The Politics of Mathematics Education”, Mellin-Olsen (1987) stated that it is a political question whether folkmathematics 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 (Skovsmose & Valero, 2002). 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 & Wedega, 2009).

In Skovsmose’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). An example of a *sociomathematical study* is found in my inquiry of adults learning mathematics (Wedega, 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. 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).

Purpose: Needs versus demands

In a study of knowing mathematics in society (mathematical literacy/numeracy) two different lines of approach are possible and intertwined in the research: a *subjective approach* starting with people's subjective needs in their societal lives, and a *general approach* starting either with societal and labour market demands and/or with the academic discipline mathematics (transformed into "school mathematics"). The general approach is obviously to be found in international surveys on mathematical literacy and numeracy like OECD (2005, 2006). This approach is also represented by the famous "Cockcroft report" with a large-scale British investigation of the mathematical needs of adult life initiated in order to make recommendations concerning the curriculum in primary and secondary schools. The title of this report was "Mathematics counts" (Cockcroft, 1982). Fifteen years later "Adults count too" was the title of a book written by Benn (1997). As the titles of the two books suggest the approaches are different. Benn started with the adults. She argued that mathematics is not a value-free construct, but is imbued with elitist notions which exclude and mystify. She recognises but rejects the discourse of mathematics for purposes of social control, where mathematical literacy is seen as a way of maintaining the status quo and producing conformist and economically productive citizens (Benn, 1997). However, to understand the affective and social conditions for people's learning processes in mathematics one has to take both dimensions into account (see Wedege, 2000; Wedege & Evans, 2006). And five years later FitzSimons (2002) published the book "What counts as mathematics?" In her discussion of technologies of power in adult and vocational education one may find the dialectic between the two approaches – the general and the subjective. In this section, my starting point is two concepts of knowing mathematics in society: mathematical literacy and numeracy.

In policy reports, international surveys, in national curricula and in research, the term "mathematical literacy" pretends to provide an answer to the question about knowing mathematics in society and does this in the terms of competencies. As with the ideas of literacy, there is a common notion of functional knowledge and of situatedness across the different constructions of concepts of mathematical literacy and of numeracy, which is crucial to the logic of competence. However, the different concepts of knowing mathematics in society (mathematical literacy) are based – implicitly or explicitly – on different notions of human knowledge and of learning mathematics (Wedege, 2003b), and they vary with the approaches, values and rationales of the stakeholders and researchers (Jablonka, 2003).

In the ALL (the Adult Literacy and Life Skills Survey), one finds a very short and still very informative definition of numeracy: "*Numeracy* – the knowledge and skills required to effectively manage the mathematical demands of diverse situations" (OECD, 2005, p. 16). The approach is general and this is about demands and requirements from society and mathematics. It is obvious from the ALL report that the ideology behind the survey is about people's ability to adapt to changes in technology and society. In PISA (Programme for International Student Assessment), the general definition reads like this:

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 this definition, the approach of PISA, which pretends to assess mathematical literacy of students near the end of compulsory education, should be subjective and starting with the needs of the individuals. 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).

In a broad definition of numeracy, we have stressed the importance of the societal context (Lindenskov & Wedege, 2001). *Numeracy* is described as an everyday competence – in terms of functional mathematical skills and understanding – that all people in principle need to have in any given society at any given time (p. 5). In our definition, numeracy is thus historically and culturally determined and it changes along with social change and technological development: numeracy in Denmark 2009 might be different from numeracy in Togo 1979. On the other hand, the definition can be seen as an attempt to combine the general and the subjective dimension. The term "in principle" makes possible a general evaluation of numeracy in the population (as in the big international surveys) and the developing of general courses in numeracy. However, all individuals who participate in a numeracy course will, in fact, have their own subjective perspectives (why am I here), their own backgrounds and needs (what am I going to learn) and their own strategies (what am I learning).

Within the construction of goals in mathematics education, there is a dualism between purposes and objectives. It is actually impossible to discuss one side of the coin without taking the other into account. In the section above, the focus was the objectives (mathematical capabilities and capacities as aims in teaching and learning mathematics). However, the pair relevance/utility ensured the link to the purposes (motives, reasons for teaching and learning mathematics). In this section, the focus is the purposes with the pair need/demands creating a link to the objectives.

Conclusion

The student asked "Why do we have to learn the division of two fractions?" But maybe he or she was really meaning "Why do I have to learn this?" What seems to be a general justification question (what is the reason for this specific part of the mathematics curriculum) is perhaps a subjective justification question (why should I engage in studying this particular aspect of mathematics). To open up to the students' individual perspectives – or foregrounds – could be the teacher's first step in a debate of goals (objectives and reasons) in the mathematics classroom. Ernest (2004) claims that there is an important perception of relevance missing from the discussion of goals in mathematics: the learners' own views of school mathematics and its relevance to their personal goals. He points out that students' beliefs of mathematics often reflects the dominant rhetoric about the importance and high valuation of mathematics in society –

not personal relevance to their own lives. According to Niss (1994), there is a contradiction between the general relevance of mathematics in society and the subjectively experienced irrelevance. He calls this “the relevance paradox” and locates the cause in the “discrepancy between the objective social significance of mathematics and its subjective invisibility” (p. 371). In the light of the discussion of relevance versus utility and of needs versus demands in this chapter, one might ask if this conflict is a paradox or just a matter of a simple confusion of relevance and utility.

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¹ In (Jensen, Niss & Wedege, 1998) the term used in this column is “objective”. We stated that the label “objective” did not imply any consideration of the validity of these reasons. The distinction between objective and subjective reasons for teaching and learning – and the two terms “objective” and “subjective” – can be seen in the context of the research and debate on vocational qualifications in the 1980's and the the 1990's where the “subjective” dimension of qualifications in terms of personal traits/attitudes such as

precision, solidarity, flexibility and the ability to cooperate came into focus. In my research on adults' mathematics containing competences in work, I have claimed that two different lines of approach are possible and necessary: *the objective approach* (the labour market's requirements with regard to mathematical knowledge), and *the subjective approach* (adults' need for mathematical knowledge in their present and future workplace) (see Wedege, 2000). However the term "objective" is very often understood as "neutral" or "un-biased", in debates with researchers. Thus, I have decided to change the term "objective" into "general" in table 1 and later in the discussion of needs versus demands as well.

² I found my inspiration to the term "sociomathematics" in *sociolinguistics*, i.e. relationships between language and society constituted as a scientific field within linguistics. But there is an important difference: sociomathematics is a field within mathematics education research (studying people's relationship with mathematics in society), not a sub-discipline of mathematics. Previously, the substantive "sociomathematics" has only been used in a meaning very similar to "ethnomathematics". Zaslavsky (1973, p. 7) 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". The adjective "sociomathematical" is used at the level of the social context of the classroom where Cobb and his colleagues developed the *sociomathematical norms* in an interpretive framework for analyzing mathematical activity with a social dimension (classroom social norms, sociomathematical norms and classroom mathematical practices) and a psychological dimension (beliefs about roles and mathematical activity in school, mathematical beliefs and values, and mathematical conceptions) (Cobb, 1996). In this framework the social category of socio-mathematical norms is correlated with the psychological category of mathematics beliefs and values. In my terminology, studies of socio-mathematical norms in a classroom would be called "sociomathematical" only if the students' relationships with mathematics *in* society are explicitly on the agenda. For example related to the students' gender, ethnicity or class.