

# Adults learning mathematics: Research and education in Denmark

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**Abstract.** In the borderland between mathematics education and adult education a new research field has been cultivated, and an international research forum is formed: Adults Learning Mathematics. The subject area encompasses formal adult mathematics education as well as adults' non-formal mathematics learning in the communities of everyday practice, e.g. the workplace. The key concept is *numeracy* and the problem field is related to mathematics and lifelong education. Danish researchers have played a role with their theoretical and empirical studies and in their engagement in the international community of research and in international networks and projects. This article presents an overview of Danish research in adults learning mathematics with a focus on the interplay between research and education. These are the key issues: What do adults know; why do adults (not) learn mathematics; why teach mathematics to adults; and how to teach or what is "best practice" in adult mathematics education. The epistemological concept of *problematique* is used as an analytical tool in this overview.

**Key words:** adult numeracy, justification, lifelong education, resistance, workplace mathematics.

*Why do you always talk about adults' problems with mathematics and never about the problems of mathematics education with adults?* (Poul Hansen, Federation of Workers in Denmark, 1995).

In the 1990s, a new research field was cultivated in the borderland between research in mathematics education and in adult education. The subject area investigated encompasses formal adult mathematics education as well as adults' non-formal mathematics learning in the communities of everyday practice, e.g. the workplace. In this context, the term *adults* refer to people who start, resume or continue their education in formal, informal or non-formal settings, beyond the normal age of schooling in their societies. In 1994, an international research forum was formed with the name *Adults Learning Mathematics (ALM)*, and Danish researchers have played a role in this work with theoretical and empirical studies, engagement in building an international community of research and co-operation in international networks and projects. As a starting point in 1995, the problem field of research in Denmark was related to basic adult education: Adult Vocational Training and Formal Adult Education. In 2000, the Ministry of Education invited two of the researchers, Lena Lindenskov and Tine Wedegé, to develop a new educational programme, *Preparatory Adult Education in Mathematics (PAE)*, in accordance with the trend of "lifelong learning" in education policy, where "lifelong" indicates that education takes place in all stages and spheres of life. In the 21st century, the right and the obligation concerning education does not stop with childhood and youth but also includes adult life. The aim of the programme PAE is that students develop numeracy, which is defined as the functional mathematical skills and understanding that in principle all people in society need to

have. The development of education and teacher education was research based and an operational model of Numeracy was the pivotal point in this work. Another education researcher, Lene Østergaard Johansen, followed the developmental process with a focus on the justification problem with a discourse analytical approach. As a statistician, Inge Henningsen has had a critical look at concept constructions and quantitative surveys; she has also taken a gender perspective.

The development of the field of practice is generally seen as an important criterion of relevance in mathematics education research. However, this is not just the ability of research to answer the problems in the field of practice, but also to criticise and reformulate these problems. The article presents an overview of Danish research in adults learning mathematics with a focus on the interplay between research and education. The organization of the article follows the structure of the epistemological frame of “problematique” as it is defined in Wedege (1997b; 2000a; 2001b; 2006) and presented below with subject area and problem field in its historical and theoretical contexts. One of the basic principles of this framework is that research is always an answer to questions — whether these are explicit or implicit. The French philosopher Gaston Bachelard (1927) puts it like this: The sense of the problem is the nerve of scientific progress. This article is presented in five major sections (a) the international scientific and ideological context for the Danish research in adult mathematics education around the turn of the 21<sup>st</sup> century; (b) the subject area of the research is presented; i.e. mathematics teaching and learning related to the Danish adult education and training system; (c) the problem field of the research with issues coming from adults learning and knowing mathematics in school and everyday life is presented; (d) the problematique of the Danish research for reformulating and answering the following questions is presented: What mathematics do adults know; why do adults (not) learn mathematics; and why teach mathematics to adults. Finally, in relation to the question what does “best practice” mean in adult mathematics education, the article concludes with a discussion on if – and how – the Danish problematique of Numeracy is reflected in educational practices.

#### **SCIENTIFIC AND IDEOLOGICAL CONTEXTS**

Around the turn of the 21<sup>st</sup> century, international developments in the scientific and ideological contexts prepared the ground for the Danish research in adult mathematics education, which focus on adults with a short educational story. The international “Adults Learning Mathematics” community of practice and research grew with the same main focus and was accepted as a domain within mathematics education research – as will be discussed below. Danish research in adult education with a focus on vocational qualifications and competences was growing in the 1990s, and – internationally – a third generation of “lifelong learning” as a guiding principle for restructuring education has taken over with consequences for adult mathematics education. At the crossroad of science, politics and ideology, international surveys on adult skills in literacy and numeracy have been carried out, with consequences for education and research.

### **Research in adult education and in mathematics education**

Adult education has been a growth area and the same is true of research into adult education. However, adult mathematics education is a relatively uncultivated area of research, but it has also been an area of increasing activity over the last 15 years. In 1994, at the initiative of British Diana Coben, inter alia, the international forum for research Adults Learning Mathematics (ALM) was formed (Coben, 1995). During the following years a community of research was created within ALM, which has been a continuous frame of reference and co-operation in the Danish research. On a personal level, ALM members like Australian Gail FitzSimons, British Jeff Evans, and Dutch Mieke van Groenestijn have been research partners. At the 8th International Congress on Mathematical Education (ICME 8), in 1996, for the first time a Working Group was organized around the theme of “Adults returning to mathematics education” with FitzSimons as Chief Organiser. In the International handbook of mathematics education, also from 1996, there was an entry for “adults” for the first time ever in a reference work on mathematics education research. And there was a whole chapter devoted to the theme of “adults and mathematics”. The authors characterized the research field as one showing “great heterogeneity” (FitzSimons et al., 1996). In the Second international handbook from 2003, “Lifelong mathematics education” was the theme of a chapter with focus on adults (FitzSimons et al., 2003). Meanwhile, a study group at the ICME congresses has become a tradition. At ICME10 in Copenhagen 2004, the name was “Adult lifelong education in mathematics” and Evans and Wedege were the Chief Organisers (Wedege et al., 2008).

In adult education research, the subject area encompasses formal adult mathematics education as well as adults’ non-formal mathematics learning in the communities of everyday practice, e.g. the workplace. The development of adult education research to an independent academic field was closely associated with the institutionalisation of adult learning. But, although the development of the field of practice is an important criterion for relevance, this is not just the ability of research to answer the problems in the field of practice, but also to criticise and reformulate these problems (Olesen & Rasmussen, 1996). Within the field of mathematics education research, relevance to the practice of teaching or learning mathematics is also a criterion of quality. The subject field is constituted by the problem field of mathematics education “in all its complexity”. However, a critical, sociomathematical approach might be opened up when studies concern the functions of mathematics education in society and in people’s lives (Wedege, 2003). One may find Nordic examples in constructions such as “folk mathematics” ( Mellin-Olsen, 1987) and “critical mathematics education” (Skovsmose, 1994).

It is an important part of the self-conception in the research field of adult education that it cannot be subordinated within a disciplinary context (such as a sub-discipline in psychology or sociology), but that inter-disciplinarity is a significant feature (Olesen & Rasmussen, 1996). The field of mathematics education research also makes use of concepts, methods and results from other disciplines (psychology, sociology, mathematics, linguistics, anthropology, philosophy). In adult vocational and further education, the reasons for teaching and learning mathematics are to be found outside mathematics. That is another reason why inter-disciplinarity is essential, both in education and research, and reconstruction of conceptual and theoretical frameworks from other disciplines is a central task (Wedege, 2000a, Wedege & Evans, 2006).

In addition, mathematics education research has a specific relationship to mathematics as a scientific discipline, as a social phenomenon, and as a school subject (Niss, 1994). What is recognized as mathematics, and what is not, is important to research, and it is also a political question; a question about mathematics and power (Mellin-Olsen, 1987; FitzSimons, 2002). Wedege (2003) has argued that conceptions like ethnomathematics have expanded the problem field of mathematics education and paved the way for studies of adults' mathematics in everyday, working and societal life. Of importance for Danish research is also Lindenskov's (1993) study of students' everyday knowledge and mathematical knowledge – especially her demonstration and exploration of the student's personal "mathematics curriculum".

In Danish adult education research and development, in the late 1980s and the 1990s, the theoretical construction of a general (vocational) qualification concept was a driving force, as adult education is closely connected with work as an individual and a social phenomenon (Olesen, 1994). In the classical German concept, *qualification* is purely determined by labour market requirements but the Danish researchers, Olesen and Illeris et al. questioned this construction:

Qualifications must be understood in their duality between the objective demands that determine them and the subjective embedding that constitutes their conditions of existence (Illeris et al., 1994, p. 28).

In importing "qualification" from Danish adult education research and re-defining the concept in the context of adult mathematics education (Wedege, 1995; Lindenskov, 1996; Wedege, 2000a; 2002b), Lindenskov and Wedege had a perspective grounded on a research interest in this conflict. In the period considered in this article (from 1995 to 2008), the international education discourse has changed from "qualification" to "competence", and today the term "competence" is almost hegemonic in educational discourses with "mathematical literacy" and "numeracy" as prominent examples of constructions (Wedege, 2001a).

A general framework for understanding adults' learning in the Danish research was found in Illeris's (2003) comprehensive theory, which combined a variety of learning theories and was based on two fundamental assumptions: (1) All learning includes two basic processes: an external interaction process between the learner and his or her social, cultural and material environment, and an internal psychological process of acquisition and elaboration. (2) All learning includes three dimensions embedded in a societally situated context: the cognitive dimension of knowledge and skills, the emotional dimension of feelings and motivation, and the social dimension of communication and co-operation.

The Danish researchers were importing and reconstructing theory from adult education research but they found their identity as members of the community of practice and research of Adults Learning Mathematics.

### **Six statements on ALM research**

As mentioned above the field of adults and mathematics was characterised as having "great heterogeneity" (FitzSimons et al., 1996). Wedege has argued that this is due to lack of a "grand narrative" concerning adults and mathematics and due to the great complexity of the subject area (Wedege, Benn & Maasz, 1998). However, her preliminary reconnaissances in the scientific landscape to identify "Adults Learning Mathematics" as a subject area, as a research domain and as a field of practice led to the conclusion that it makes sense to speak about ALM as "a community of practice and

research”, in spite of this heterogeneity. The reconnaissances resulted in five statements (1-5) on the international research forum of ALM (Wedeg, 2000a, 2001b). In her reading of ALM literature, Johansen (2006) has added a sixth statement on the discourse within the research community of ALM:

(1) Preliminary place in the scientific landscape:

*The ALM community of practice and research is accepted as a domain within mathematics education research.*

Since 1997, the identity of the research domain in ALM has been debated at the annual conferences (Wedeg, 1997b). An important question in the debate was this: Where is the research domain situated? (Wedeg, Benn, & Maasz, 1998). This is not just an academic question without any consequences for practice and research. When we know where we are – or want to be - in the scientific landscape, we know something about scientific legitimacy and about criteria of quality and relevance. Wedeg (2000a, 2001b) has argued and claimed that “adults learning mathematics” is situated in the borderland between research in mathematics education and in adult education from where we import and reconstruct concepts, theories, methods and findings. FitzSimons (2002) sees her work on the borderlands of three fields: mathematics education, adult education and vocational education – connecting all three. And she continues: “Perhaps it is due to these borderland crossings that my research is often located at the margins of each of these research communities” (p.2). However, as documented above, ALM is accepted as a research domain of some of the central academic institutions within mathematics education research.

(2) Subject area:

*The learner is the focus of the ALM studies, and her/his “numeracy” is understood as mathematical knowledge.*

In the aim of the research forum it is stated: “Within ALM we understand the term “mathematics” to include “numeracy”” (Coben, 1995, Preface). Adult numeracy is the main construct in the subject field. In English speaking countries, the term “numeracy” is used for certain basic skills and understandings in mathematics which people need in various situations in their daily life. Numeracy is a key word in basic adult mathematics education. As a concept, however, numeracy is deeply contested in politics, education and research. Nevertheless, as an analytical concept, adult numeracy may be considered as mathematical activity in its cultural and historical context. (For a review of international research and related literature on adult numeracy, see Coben et al., 2003.) Numeracy versus mathematics has been debated in a series of ALM papers as well as in the European Network for Motivational Mathematics for Adults (EMMA, 2005-2007). Using the analytical framework of Bernstein, FitzSimons (2002) has argued that numeracy is a *horizontal discourse* which draws upon foundations of mathematical knowledge developed by individuals over a lifetime of personal experience and enculturation but which, unlike the *vertical discourse* of the discipline of mathematics, relies on common sense and is specific to and dependent on contexts.

(3) Problem field

*Research questions in mathematics education are integrated with general adult education questions in ALM and the studies are interdisciplinary.*

The focus on the adult learner with capacities developed throughout a lived life is argued and developed with reference to the principles of andragogy, e.g. that adults need to be involved in the planning and evaluation of their instruction, and that experience (including mistakes) provides the basis for learning activities (Benn, 1997; Lindenskov, 2006a). Research questions related to this might concern the adult's personal relationship with mathematics like anxiety or blocks. Other central phenomena to be studied are adult numeracy and activities in working and everyday life. This calls for theories and conceptual frameworks outside mathematics education and is another reason for interdisciplinarity. The construction or reconstruction of conceptual frameworks is important tasks in research. Lave's anthropological theory of situated learning and Engeström's psychological theory of expansive learning are two examples of general theories that have been used and re-interpreted in studies of adults' mathematics in work (Wedge, 1999; FitzSimons, 2002).

(4) Two perspectives:

*The duality between the general and subjective perspective is either implicit or explicit in all ALM problematiques.*

Two different lines of approach are possible and intertwined in the research: *the general line of approach*, starting either with societal and labour market requirements with regard to adults' mathematics-containing competences or with demands from the academic discipline (transformed into "school mathematics"), versus *the subjective line of approach* starting with adults' need for mathematics-containing competences and their beliefs and attitudes towards mathematics (Wedge, 2000a). The general approach is obviously to be found in international surveys on adult literacy and numeracy like OECD (2000, 2005). This approach is also represented by 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 the report was "Mathematics counts" (Cockcroft, 1982), and it is to be found among the references in nearly all research papers on adults and mathematics in the 1990s. Fifteen years later "Adults count too" was the title of a book written by a prominent British ALM member, Roseanne Benn (1997). The two books examine the low level of numeracy in society, but the approaches are quite different. The approach of Benn was the subjective, starting 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. Similarly, she rejects the approach where any problem with mathematics is located within the learner rather than the system (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, and five years after "Adults count too", another ALM member FitzSimons (2002) published her doctoral thesis entitled "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.

(5) Justification problem:

*The overall purpose of ALM practice and research is “empowerment” of adults learning mathematics.*

The fifth statement was a conclusion of the debate of Adults Learning Mathematics as a community of practice and research at ALM5 (Wedeg, Benn, Maasz, 1998). This is also reflected in some of the titles of the yearly conferences; for example ALM8 in Denmark: “Numeracy for empowerment and democracy?” (Johansen & Wedeg, 2002) and ALM15, in 2008 in the USA: “A declaration of numeracy: Empowering adults through mathematics education”. The former opened a debate. The main issue addressed was numeracy as a possible answer to questions of empowerment and democracy in the broadest sense of these terms. No single answer was found and new questions were raised. On the basis of a discussion of two conceptions of democracy, Lindenskov and Valero (2002) presented examples of educational practices which could easily end up generating disempowerment of the students although the opposite was intended. On the basis of her studies of the justification problem in adult mathematics education, Johansen (2002b) presented and discussed the consequences of different conceptions of active citizenship.

(6) Discourse:

*Two grand stories, “the school subject curriculum model” and “the ethno curriculum model”, are located in the researcher-practitioner discourse.*

The two “stories” were constructed by Johansen (2006) on the basis of her reading and interpretation of the discourses found in the ALM literature. According to her, the first story, based on “the school subject curriculum model”, is often saying what “we” in ALM do not want, or else it is presented as a model for “adult independent learning” where adults study school mathematics at home. The focus and starting point in this model for teaching adults numeracy is their lack of formal and basic mathematical skills. The second story, based on “the ethno curriculum model”, talks about “an ideal model” of adult mathematics education, which “we” in ALM really want, according to Johansen. In this model, the focus and starting point is that adults are already in possession of mathematics-containing knowledge before they enter a numeracy course, even though they may not be aware of their own competences and even though they may think that “maths is something I can not do”. Johansen concludes that – despite the lack of a “grand narrative” – it is possible to talk about an ALM Discourse. In the European project *Adult Life Mathematics Across Borders* (ALMAB), which aims at exchanging good teaching materials and good practices between countries, a paradox of two similar trends in adult mathematics education and research has been faced. The project confronts the trend towards ethnomathematics, which acknowledges mathematics of different cultural groups, with the trend towards internationalisation – or globalisation –, which tends to neglect cultural characteristics (Lindenskov & Helmer, 2003).

**Lifelong adult education**

The rhetoric of lifelong learning is supposed to structure education in the Nordic countries, and the rights and the obligations concerning education do not stop with childhood and youth but include adult life. According to Rubenson (2001), in the late

1960s UNESCO introduced lifelong learning as a utopian-*humanistic* guiding principle for restructuring education. The concept disappeared from the policy debate but reappeared in the late 1980s in a different context and in a different form. The debate was now driven by an interest based on an *economistic* worldview, emphasising the importance of highly developed human capital, and science and technology. From the first to the second generation, lifelong learning had changed from a utopian idea to an economic imperative. This restricted, economistic view has been severely criticised and, from the late 1990s, it seems that a third generation (*economistic-social cohesion*) with active citizenship and employability as two equally important aims for lifelong learning – at least on the rhetoric level – is taking over. I find that the change in educational discourse from qualification to competence mentioned above is a possible consequence of change from the second to the third generation of the notion of lifelong learning. It is also possible to see the theme formulated by the international programme committee for the debate of Discussion Group 3, at ICME-10 in Copenhagen 2004 (Lindenskov et al., 2008), as an illustration of one of the dilemmas built into the third generation: Mathematics for whom and why? The balance between “mathematics for all” and “for high level mathematical activity”.

As a discourse of education, lifelong learning assumes that learning takes place in all spheres of life, not only in schools and institutions: as formal and non-formal learning in education and training programmes, and as informal learning in the workplace and the adults’ everyday lives. According to the terminology of UNESCO (2000, p. 41), *informal education* means the truly lifelong process whereby people acquire attitudes, values, skills and knowledge from daily experience and the educative influences and resources in his or her environment – from family and neighbours, from work and play. For the most part, this process is relatively unorganized and unsystematic. *Formal education* refers to the highly hierarchically structured, chronologically graded educational system, from primary school through to university and includes a variety of specialized programmes and institutions for technical and professional training. *Non-formal education* is defined as any educational activity organized outside the established formal system that is intended to serve identifiable learning objectives.

The first generation of lifelong learning saw a strong role for civil society while the second generation privileged the market, downplayed the role of the state, and almost totally neglected civil society. In the third generation, the market still has a central role but the responsibilities of the individual and the state are also visible. According to Olesen (2002), in adult and continuing education there seems to be two parallel and combined processes going on: an institutionalizing process adding schools for adults to the schools for children and adolescents, and a de-institutionalizing process with a focus on adults’ learning processes outside schools.

As we have seen, the concept of lifelong learning is not formed on a national level but on an international level (e.g., UNESCO, OECD, EU). It is a globalised idea being reinterpreted on the national level. In the official Danish documents concerning lifelong learning from the late 1990s one recovers the discourses of the third generation as well as in the documents at the beginning of the 21<sup>st</sup> century:

Excellent development and learning opportunities for children, young people and adults shall strengthen personal development, employment and active participation in society of the individual. (...) This is crucial for raising the level of education and strengthening competitiveness and cohesion in Danish society (Danish Ministry of Education, 2007, p.1)



Lindenskov (2006b) has stressed how numeracy and mathematical literacy have a central place side by side with literacy in political documents from UNESCO and from the European Commission on the key competences required in the society of tomorrow. In Denmark, this is illustrated by the new programme of Preparatory Adult Education (PAE) with literacy and basic mathematics offered to adults since 2001. The new tendencies in the third generation of “lifelong learning,” with a combination of economics and social cohesion, are also visible in this programme. During the political debate and the educational planning process of PAE Mathematics, “active citizenship”, “employability” and “personal needs” were used as equivalent arguments (Johansen, 2002). An obvious danger of lifelong learning as a political project is that learning for active citizenship and democracy is reduced to an individual project. From this point of view, it is important to notice that the following statement was formulated by the Danish government in the Bill of Preparatory Adult Education (Forberedende VoksenUndervisning), in 2000:

Further development and maintenance of the individual’s skills are not *only* an individual and private affair and responsibility. It is *also* a common societal responsibility. PAE encompasses both a democratic aspect to maintain and promote the development of active citizenship and an economic perspective linked to the demands and needs of the labour market.

### **International surveys on adults’ basic skills**

At the crossroad between science, policy and ideology, are the OECD surveys on adult literacy and numeracy, which in this context are named “basic skills” or “key competences”. The survey results play a major role in public debate on education and labour market policies and they have consequences for political decisions regarding the education system and resources for research in adults’ skills. Jablonka (2003) investigated different perspectives on mathematical literacy and numeracy. Her message is that any given conception of mathematical literacy promotes a particular social practice. For example, she argues that the attempts in OECD surveys (e.g., PISA) of developing a cross-cultural definition of mathematical literacy for the purpose of generating measurable standards promote mathematical literacy for developing human capital; i.e. these construct belong to the second – economic – generation of lifelong learning. This also holds true for the construction of literacy in the International Adult Literacy Survey (IALS), where the aim was to obtain uniform and thus comparable results in the 1990s from 20 countries about the populations’ skills, which were categorised into five levels within each of the three proficiency scales (prose, document and quantitative literacy) (OECD, 2000). Compared with adults in other countries, the populations in the Nordic countries had high test scores. Almost three quarters of the Danish population scored at the three highest levels in quantitative literacy, while approximately two thirds were at those levels with respect to document literacy. Just over half of the population had prose literacy skills at the three highest levels.

However, despite the generally good levels for Denmark, the literacy skills of a fairly large number of Danes were deemed inadequate when judged on the basis of the test used in the OECD survey. Depending on the scale in question, between 28% and 46% of the population between 16 and 66 years were thus claimed to have inadequate literacy skills for the demands made on them at work and in everyday life (Jensen & Holm, 2000). In Denmark these results, published in 2000, were used by the social-democratic government of the time as an argument in the political debate prior to their adult

educational reform in which a very important element was to strengthen basic skills such as literacy and numeracy. The new programme Preparatory Adult Education, with mathematics as one of the lines, was offered from 2001.

The subsequent OECD survey, The Adult Literacy and Life Skills Survey (ALL), might be seen as a corrective to the IALS; and a framework for adult numeracy was constructed by a group of ALM members (see Groenestijn, 2002) on the basis of the following definition: *Numeracy* is the knowledge and skills required to effectively manage the mathematical demands of diverse situations. The title of the first concluding report from ALL, “Learning a living”, reflects the age of lifelong learning and “change” is the theme which is struck in the preface:

Change is a defining feature of modern life. Technologies change, the organization of work changes, terms of trade change, communities evolve and social roles change as individuals negotiate the life course. Hence change is unavoidable. It obliges individuals, families, schools, firms and nations to adapt. (...) The ability to adapt to change depends, to a large extent, on the pool of skills upon which individuals, institutions and nations can call (OECD, 2006 p. 3).

Here, the ability to adapt is emphasized as in the qualification analysis of the labour market in 1980s. Even though people’s societal life is described as one of the contexts for numerate behaviour in the theoretical framework of numeracy, I find more second generation development of Human capital than active citizenship in this discourse. The validity of the OECD-surveys has been questioned from various perspectives inside and outside the ALM community. Some of this criticism is presented below.

These were – and still are – the scientific, political and ideological contexts of Danish research and developmental work in adult mathematics education.

#### **SUBJECT AREA: ADULT MATHEMATICS EDUCATION**

By *subject area*, I mean the area to be investigated in research. Following Niss (1999), I describe the subject area in *classical mathematics education research* as stretching between and combining the following three main areas: (1) *the teaching of mathematics* with focus on matters pertaining to organised attempts to transmit or bring about mathematical knowledge, skills, insights, competencies, and so forth, to well-defined categories of students; (2) *the learning of mathematics* with focus on what happens around, in and with students who engage in acquiring such knowledge, skills, etc., with particular regard to the processes and products of learning; (3) *the outcomes* (results and consequences) of the teaching and the learning of mathematics, respectively. Besides these three interrelated areas, the field of mathematics education research itself is made the subject of investigation in theoretical and empirical studies. In classical research, the interest is mainly children and adolescents in formal education.

At any given time, the subject area is “always-already” structured and delimited by the concrete forms of practice and knowledge that are currently regarded as mathematics teaching, learning and knowing. When mathematical knowledge is not only seen as academic mathematics and school mathematics but also as everyday mathematics then mathematics teaching and learning encompasses informal activities outside schools and education institutions. If people’s attitudes are seen as important for

the learning and the knowing of mathematics then the affective dimension is a possible focus when learning and outcomes are studied.

The subject area is both delimited and widened in *adult mathematics education research* (see Wedege, 2000a). The three main areas are: (1) *adult mathematics teaching*, which encompasses mathematics-containing instruction in vocational education (e.g., apprenticeship); (2) *adults learning mathematics*, where the context for learning is widened to everyday and working life – from formal and non-formal to informal learning; (3) *adult mathematical knowledge and adults' attitudes towards mathematics*, where mathematics-containing competences are seen as a prerequisite for learning, not only as outcomes, and where the affective dimension of people's relationship with mathematics is included.

In the Danish research, the subject areas are found in and around the adult education and training system where mathematics teaching, learning and knowledge/attitudes are investigated; and in workplaces where knowledge/attitudes are studied. In the following, I give a short presentation of the adult education system with a special focus on basic adult mathematics education.

### **Formal and non-formal education**

In Denmark, adult education is extensive and based on a long tradition, as in the other Nordic countries. It is provided in many different forms and under many different auspices, ranging from national or municipal adult education to labour market and staff training and competence development at work; and also ranging from liberal adult education activities (non-formal education) to qualifying general as well as vocationally oriented adult education (formal education). The adult education system is built up in parallel with the mainstream education system, and mathematics is offered to adults at lower and higher secondary levels (see figure 1). In the area of Vocational Education and Training (VET) there is a longstanding tradition of involving the trade unions and the employer's associations, who have been attributed significant influence. Publicly financed adult education can be roughly divided into three main categories (see figure 1):

- Adult liberal education (e.g. basic mathematics courses at evening schools)
- General adult education (e.g. numeracy and mathematics at primary and secondary levels)
- Vocationally oriented adult education and training from VET level (e.g. a mathematics-containing truck-driving course) to the highest academic level (e.g. a Masters degree in mathematics).

Only the education in the last two sectors offers formal qualifications.

One intention within the adult education system is that the work and life experiences of the adult play an important role in connection with the organisation of the education programmes as well as in their content, profile and duration.

Adult Education and Continuing Vocational Training					Mainstream Education System			Years of Education
Liberal Adult Education	General Adult Education	Adult Vocationally Oriented Education						
				Masters Level			Long-cycle Higher Education	13 <sup>th</sup> -17 <sup>th</sup>
				Diploma Level			Medium-cycle Higher Education MVU	13 <sup>th</sup> -15 <sup>th</sup>
				Further Adult Education	Short-cycle Higher Education KVVU		Bachelor	13 <sup>th</sup> -14 <sup>th</sup>
		Continuing Vocational Training CVT & Adult Vocational Training AMU						
Folk High Schools & Day Folk High Schools & Evening Schools	Higher Preparatory Education HF		Adult Vocational Education VEUD	Basic Adult Education GVVU	Vocational Education & Training		Advanced Upper Secondary School	10 <sup>th</sup> -12 <sup>th</sup>
	General Adult Education AVU							9 <sup>th</sup> -10 <sup>th</sup>
	Preparatory Adult Education FVVU				Primary and Lower Secondary School			

**Figure 1.** The Danish adult education and training system at the beginning of the 21<sup>st</sup> century (Source: [www.uvm.dk](http://www.uvm.dk)).

Mathematics instruction covers a wide variety of activities. *Mathematics instruction* (organised communication of a mathematical subject area, either as a single-subject or as an independent subject or module within an educational programme) can be found in all three sectors, as well as *mathematics-containing instruction* (communication of a single or interdisciplinary subject area where mathematics is an integrated but identifiable part) (Wedegge, 2000a). In adult and continuing training programmes, the objectives range from a purely job-related or concrete supplementary training view, over a broad vocational view to a societal view. It is possible to locate two different objectives in mathematics and mathematics-containing instruction: knowledge and

abilities concerning mathematics as a subject in itself, and mathematics in relation to other subjects. Furthermore, the instruction can be organised in two different ways: mathematics taught as a separate subject or as a part of and integrated into other subjects (see figure 2).

<b>Objective Organisation</b>	<b>Focus on mathematics</b>	<b>Focus on other subjects</b>
<b>Mathematics as a separate subject</b>	General Adult Education Higher Preparatory Education	Adult Vocational Training & Education
<b>Mathematics integrated in other subjects</b>	General & Preparatory Adult Education Adult Vocational Education	Adult Vocational Training & Education

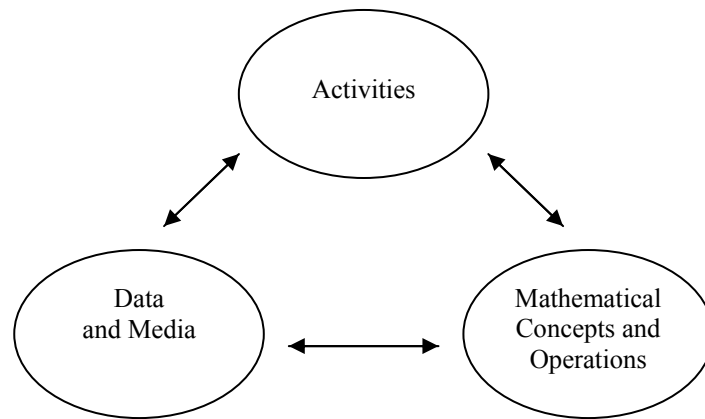
**Figure 2.** Two dimensions of formal mathematics and mathematics-containing instruction in Danish Adult Education (Wedeg, 1998a, p.182).

In Danish research the subject area within formal education is found in *Adult Vocational Training* (courses giving formal qualifications to semi-skilled workers, skilled workers and middle management) and in *Formal Adult Education* (general education at lower secondary level organized as single subject). Since 2000, the programme *Preparatory Adult Education* (PAE, Da: Forberedende Voksenundervisning) and the teachers involved play a special role as it has both been subject of developmental work (Lindenskov & Wedeg, 2001; Wedeg, 2007) and of research (Henningsen & Wedeg, 2003; Lindenskov, 2006a; Johansen, 2006).

### **Preparatory Adult Education in mathematics**

In January 2000, the Ministry of Education invited Lindenskov and Wedeg to develop the national mathematics curriculum and teacher training for the new programme Preparatory Adult Education, which also contains a literacy curriculum. From the autumn of 2001, basic, preparatory mathematics has been offered to adults. The purpose is formulated as to ensure students the possibility of clarifying, improving and supplementing their functional arithmetic and mathematical skills. The intention of the education is to increase the students' possibilities of coping with, processing and producing mathematics containing information and materials.

A specific terminology is used and defined in the curriculum of PAE mathematics. The aim is formulated as the adult students' further development of their *numeracy* (a term that will be defined in the next section). The content is described as a dynamic interplay between a series of *activities* (counting, locating, measuring, designing, playing, explaining) with inspiration from Bishop (1988), various types of *data and media*, as well as selected *mathematical concepts and operations* (see figure 3).



**Figure 3.** The content of the curriculum presented as a dynamic interplay (Lindenskov & Wedege, 2001, p. 19).

PAE mathematics has two levels: (level 1) *figures and quantity* and (level 2) *patterns and relations*, which in addition include the area of form and dimension, as well as data and chance. At level 1, the content is described like this:

Activities:

- Counting (reading numbers, sorting, comparing, calculating)
- Measuring (surveying, weighing, comparing, calculating, converting)
- Locating (denoting place, time and direction)
- Playing (following rules and strategies)

Data and media:

- Amount, time, price, discount, loss, weight, temperature, volume, length, distance, numbers, and dates.
- Written information and communication (informative and instructive texts, reference and fill-in texts), oral information and communication, concrete materials.

Mathematical operations and concepts:

- Cardinal numbers, ordinal numbers and codes and numbers.
- Less than, more than, equal to, the same as and different from.
- The positional system.
- Units (metre, litre, kilogram, hours) and conversion.
- Addition, subtraction, multiplication, division of whole numbers, and decimals using aids.
- Special figures and connections usable in mental arithmetic and estimations.
- Special fractions ( $\frac{1}{4}$ ,  $\frac{1}{2}$ ,  $\frac{3}{4}$ ,) and percentages (10%, 25%, 50%).
- Length, height, breadth, and perimeter.

(Lindenskov & Wedege, 2001, pp. 20-21)

According to the curriculum, mathematical awareness is cultivated and trained in the students. The course aims to make it possible to clarify and formulate, and maybe change, students' beliefs and attitudes to mathematics. Students should work with

several different kinds of contexts. In addition to the mathematical context, they should work with everyday and societal contexts. The class decides upon the choice of context for whole group activities. With regard to individual activities, the individual students choose their contexts on the basis of what they need to learn.

The organisation, concrete aims and content should be arranged so that the background and foreground of the students take centre place. Dialogue is used to clarify and make use of the students' background and foreground. The relevance of the content is made clear by concrete connections to activities outside education. The way the problems are posed and formulated as well as the problem solving methods should be authentic in relation to the chosen context.

### **PROBLEM FIELD OF ADULTS LEARNING AND KNOWING MATHEMATICS**

The subject area of "adult mathematics education" is being cultivated, research problems are formulated in a dialectic relationship with practice and the subject area is growing into a subject field. When the researchers explicitly start to locate and formulate problems concerning phenomena within the subject area, then it is further structured and the *subject field*, i.e. the field which is actually investigated, is created. Taking their point of departure in a specific position, the researchers adopt a certain view of the subject and identify a *problem field* concerning the subject area by locating and formulating *problem complexes*. In ALM research the learner is in focus and the problems might be, for example, "how can adults' every day experiences constitute the basis for learning mathematics?" (Lindenskov, 1998b); "how can adults' mathematical understandings become identified with common sense?" (Wedege, 2002a); "how can the discrepancy between the adults' self-assessed proficiency and the results of the international surveys be explained?" (Henningsen, 2008a); and "who are the potential participants in PAE mathematics?" (Johansen, 2002c). The main subject fields in mathematics education research (teaching, learning and knowing mathematics) are structured from the perspective of the three classical didactical questions (what, how and why). In "Adults Learning Mathematics" they are supplemented by questions like "Who are the (potential) students in adult mathematics education" and "Where do adult learn and use mathematics and under what circumstances".

#### **Problem complexes**

From the beginning, two main problem complexes have given fuel to the Danish research: (1) adults' cognitive, social and affective relationships with mathematics and (2) adult mathematics in vocational training and in the workplace. *Profiles in the mathematics of adults* was the name of the first Danish developmental project combined with research in adult mathematics education. The project crossed the two programmes Adult Vocational Training and General Adult Education and the purpose was to create a basis for advising the individual student returning to mathematics education on a point of departure for his/her mathematical skills development. The aim was to develop guidance materials for students and teachers, which include adults' capacities structured in working and everyday life (Wedege, 1997a; Lindenskov, 1998b). As a starting point in this project a series of potential problems on the students' relations to numbers and mathematics was formulated as items in a survey conducted at the adult and vocational training/education centres. This survey confirmed that the teachers agreed upon the

following: many students are blocked in relation to numbers and mathematics; for the students theory is one thing, practice is quite another; and many students lack fundamental skills in arithmetic and mathematics. In the next project, *Vocational Mathematics* (Wedege, 1998b), these three issues were reformulated with a subjective approach and investigated in qualitative interviews with 45 students at the Adult Vocational Training Centres. A general problem for understanding mathematics located in the teaching was then formulated on the basis of the adults' stories: "It is because I do miss pictures ..." (Lindenskov, 1996). The students' blockage and resistance was another issue investigated. In adult education, resistance to learning is a well known phenomenon. Often adults' resistance in the learning situation has to do with the fact that they have experienced themselves as competent persons without mathematics, and that mathematics has not been perceived as relevant to their life project (Wedega & Evans, 2006). This problem – among others – is reformulated and studied in the international project *Adults learning mathematics in school and everyday life*, which aims at establishing an interdisciplinary theoretical framework to describe, analyze and understand social and affective conditions of adults' learning processes.

Another problem is mathematics as a gate-keeper. To many adults "Mathematics that's what I can't do" and the door named mathematics to further education is closed (Wedega, 2002a). The issue of exclusion and inclusion in and by adult mathematics education is thematised by Johansen (2002a) and also by Lindenskov (2006b), who – in an article on mathematics difficulties in general – clarifies a distinction between inclusion and integration of students with learning difficulties. According to her, both notions imply that everybody – students with special needs as well as others – are admitted and participate in the school. However inclusion is more extensive than integration because the process of inclusion is two-sided. It involves more than adaptation and challenges the way mathematics is taught "normally" in the school. Another issue related to equality is gender mainstreaming discussed by Henningsen (2008b). Mainstreaming has been widely adopted by the international community, and a growing body of research explores how pluralism and multiculturalism in mathematics education affect people's mathematical understanding, attitudes and participation. Gender mainstreaming investigates how cultural and economic factors influence the formation of female and male differences in these areas. However, as Henningsen (2002, 2008b) has shown, gender mainstreaming of adult mathematics education is not on the agenda anywhere today – neither in curriculum planning nor in international surveys.

As a consequence of the involvement in reforms and in teacher education programmes in adult mathematics education, it was also found relevant to formulate problem complexes on the teachers' attitudes towards mathematics (Henningsen & Wedega, 2003) and on their approaches to teaching mathematics to adults (Lindenskov, 2003b). Defining dilemma as a 'right-right' choice situation Lindenskov and Hansen (2001) present two dilemmas which they consider as general in teaching adult basic mathematics. The first dilemma is how to meet the adult learners' already established conceptions and procedures. It is often recommended to help adults become aware of their methods to calculate, approach and solve problems in mathematics. But their observations and interviews in a classroom challenged this idea. The second dilemma concerns the influence of the learners. According to the Danish curricula, the students participate in the ongoing planning of the course (for example, they decide upon the themes – art, food, transport, etc.) but how are the students provided the adequate



information upon which to base their decisions? . Lindenskov and Hansen do not see one and only one right answer but they expect teachers to be able to reflect on several good answers.

One of the fundamental reasons given for providing mathematics education refers to the labour market. Mathematics education should provide students with qualifications for their working lives and contribute to the technological and socio-economic development of society (Johansen, 2002a). However, in international policy reports concerning the requirements of technological change in society, the general categories of qualifications and competences are described in isolation from the technological contexts of workplaces. As a consequence, complexity of workplace competences is reduced and the use of mathematical knowledge in workplace situation is seen as a simple question of knowledge transfer. This exemplifies two problems that the researchers agree upon (see Wedege, 2004):

- Mathematics is integrated in the workplace activities and often hidden in technology (e.g. Strässer & Zevenbergen, 1996; FitzSimons, 2002; Wedege, 2000a).
- The so-called “transfer” of mathematics between school and workplace – and vice versa – is not a straightforward affair (e.g. Evans, 2000; Lindenskov, 1996, 1998a; Wedege, 1999, 200b,2002b, FitzSimons & Wedege, 2007).

In the Danish AVT programmes it has been a tradition since the late 1980s to cooperate with researchers in adult education (e.g. Olesen and Illeris) in educational planning and teacher training. However, as late as the mid 1990s, there had not really been any research in adult mathematics education, either in Denmark or internationally. No help was to be found to answer questions like “What mathematics should be taught in adult vocational training and how?” Hence, the abovementioned analytical project, *Vocational Mathematics*, was initiated to address numbers and mathematics in Adult Vocational Training (Wedege, 1998b). One central issue was in line with the general problem complex on transfer and concerned differences between mathematics in school and in the workplace. Another issue was in line with the problem complex on mathematics being integrated within the workplace activity and concerned the workers’ mathematics-containing competences.

### **Terminology**

The subject field is also structured, opened and delimited by the researchers’ concepts and terminology. In English speaking countries, “numeracy” is a key word in basic adult education, but in the mid 1990s, the Danish language did not have a single expression corresponding to the term “numeracy”. Nevertheless, Lindenskov and Wedege (1997) chose to use the term *numeralitet*, which was later adopted by the Danish Ministry of Education. In their definition:

- *Numeracy* consists of functional mathematical skills and understanding that in principle all people need to have.
- Numeracy changes in time and space along with social change and technological development (Lindenskov & Wedege, 2001, p. 5)

It is the expression “in principle” that makes possible a general assessment of adult numeracy and the development of general courses in numeracy. All adults who

participate in a numeracy course will, in fact, have their own foregrounds, their own backgrounds and needs and their own strategies for learning. In the above definition, numeracy is historically and culturally determined and it changes along with social change and technological development: Numeracy in Denmark 2008 might be different from numeracy in Togo 1978. It is this definition of numeracy which is adopted as the aim in the national curriculum of PAE-mathematics.

The term *everyday mathematics* is another example of a phenomenon in the subject field to be investigated. As a matter of fact, it was debated during the developmental process of PAE about whether to name the course “everyday mathematics” instead of “mathematics” (see Johansen, 2006, p. 195). The subject field is elucidated when Lindenskov (2004) inquires: “What do we mean by everyday mathematics in adult education?” In this article she discusses three categories of subjects/phenomena named “everyday mathematics”: *titles* for educational programmes, national curricula and mathematics textbooks; *pictures* provided by course mathematics when phenomena, things and activities from outside school are represented in learning materials and communication within the classroom; and *activities* involving “real world” mathematics as in folk mathematics, street mathematics and ethnomathematics.

Another term often used in literacy and numeracy studies is *functional*. In PAE mathematics the aim was formulated as intending the students to develop functional mathematical skills and understandings. When Johansen (2004a) asks what do “functional skills and understanding” mean in adult mathematics, she distinguishes between four different analytical domains in adults’ lives (school, workplace, everyday life and democratic) and she studies functional skills from four different discursive perspectives (society/politicians’, researchers’, mathematics teachers’ and individuals’). Her analysis emphasizes that skills and understanding can be functional in one domain from one perspective and not functional in another domain or from another perspective.

*Context* is term often used in mathematics education and relevant, for example, to problems of transfer/transition and to these clarifications of “functional”. Wedege (1999) asks what does “context” mean in mathematics education? She locates two meanings and proposes a terminological distinction. One is where context represents reality in tasks, word problems, examples, textbooks, teaching materials etc. (e.g. everyday life situations evoked in a problem-solving task). Wedege calls this type *task context*. The other fundamental meaning has to do with contexts for learning, using and knowing mathematics (e.g. school, everyday life, workplace), or contexts of mathematics education (e.g. education system, education policies) and this type is named *situation context*.

In order to investigate the relationship between mathematics education and technology in the workplace, it is necessary to have broad conceptions of mathematical knowledge and of technology in the workplace. Realising that there is more to technological development than new machinery, Wedege (1995, 2000c) defines *technology* on the labour market as consisting of three elements: technique, human competences and qualifications, and work organization – and of their dynamic interrelations. *Technique* is used in the broader sense to include not only tools, machines and technical equipment, but also cultural techniques (such as language and time management), and techniques for deliberate structuring of the working process (as for instance in Taylor’s ‘scientific management’ and ISO 9000 industrial quality certification). *Work organization* is used to designate the way in which tasks, functions, responsibility, and competence are structured in the workplace.

*Mathematics-containing technology* is technology where mathematics is an integrated but potentially identifiable part. This term “mathematics-containing”, which is used above, is imported from German, translated and defined (Wedge, 2000a). With the term “mathematikhaltigen Weiterbildung”, Jungwirth, Maasz and Schlögmann (1995) opened a subject field for research on vocationally-oriented adult education in which mathematics is an integral part.

#### **PROBLEMATIQUE FOR RESEARCH IN ADULTS LEARNING MATHEMATICS**

“Could there be a specific problematique for research in adult mathematics education?” This question was debated at the Fourth International Conference on Adults Learning Mathematics, in Limerick (Wedge, 1997b). The research area in adult mathematics education research stretches between the phenomena of adult mathematics teaching, learning, knowing and adults’ attitudes and emotions towards mathematics. Subject fields are structured by problems and research questions formulated on the basis of a specific theoretical and/or methodological approach, and a systematically linked problem field, a *problematique* for research in mathematics education, is construed. Any problematique is, for example, based on a specific conception of mathematical knowledge, of how to learn mathematics and of global reasons for mathematics education (Wedge, 2006). As demonstrated through the six statements on ALM research presented above, her answer to the initial question was that there are a series of common and specific characteristics in the research within the community of ALM (Wedge, 2001b). But in adult mathematics education there are also incompatible problematiques. As an example, results from an international survey like Adult Literacy and Life Skills (OECD, 2005) – presuming that it is meaningful to measure people’s numeracy with the same tool across different countries and cultures – can not complement results from comparative investigations from an ethnomathematical perspective, which emphasizes the local and the culturally specific (Bishop, 1988). In both cases, the subject area is people’s mathematical everyday competences, but the subject field (what is actually investigated) is construed differently because of different research interests and questions, theories and methodologies.

In the light of this short presentation of a concept and a context, it is relevant to ask if there exists a problematique for Danish research in adults learning mathematics. In her study of the justification given explicitly and implicitly through the discourses of the politicians and the researchers involved in PAE, Johansen (2005b, 2006) presents arguments which might be understood as a positive answer to this question. Her analytical framework includes the four didactical questions: Who is going to learn? What is going to be learned? How is it going to be taught? Why should it be taught? The analysis of the discourses, from the period 1996-2001, revealed that Lindenskov and Wedege gave the same or compatible answers concerning who, what, how and why. Thus, a preliminary conclusion might be that they work within the same problematique. In what follows we shall see that the background for this – and what is actually constituting “our” problematique – is the construction of numeracy as a key concept and an analytical tool based on socio-cultural theories and research.

#### **Numeracy as a key concept and an analytical tool**

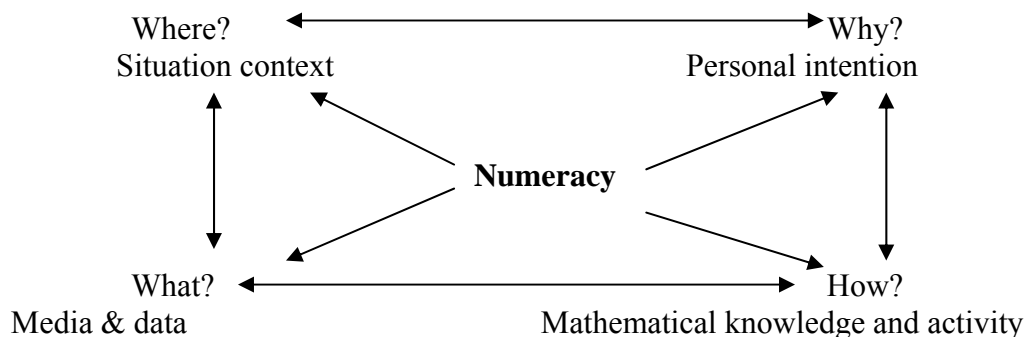
Our general definition of numeracy as an everyday competence needed in principle by all people in society, presented above, was formulated within a general approach

(societal needs). But in order to capture complexity of numeracy in people’s everyday life within a subjective approach (individual needs), Lindenskov and Wedege have given it an operational definition and constructed a working model with four analytical dimensions: context, media, skills and understanding, personal intention. This model has been used and further developed as an analytical tool in Danish adult mathematics education and research (e.g. Lindenskov, 1998a&b; Wedege, 1998b, 2000a, 2004; Lindenskov & Wedege, 2001; Johansen, 2004b, 2006).

The genesis of the working model began in the project *Profile in Mathematics of Adults*, juxtaposing concepts of literacy in international studies with central concepts in mathematics education research. However, working with the problems of adults’ profile in mathematics Lindenskov realised that there is more to adult numeracy than mathematical skills and understandings (Lindenskov & Wedege, 1997). Thus, during the research and development work in the Adult Vocational Training system, they (Wedege, 1998b; Lindenskov & Wedege, 2001) developed an operative model for *Numeracy* with four interrelated dimensions for the study of adult numeracy:

- *Media* (a) written information and communication (b) oral information and communication, c) concrete materials, d) time, and e) processes.
- *Context* - in the meaning of situation context - (a) working life, (b) family life, (c) educational context, (d) social life, and (e) leisure.
- *Personal intention* (a) to inform/be informed, (b) to construe, (c) to evaluate, (d) to understand, (e) to practise, etc.
- *Skills & Understanding* - Dealing with and sense of (a) quantity and numbers, (b) dimension and form, (c) patterns and relations, (d) data and chance, (e) change, and (f) models.

Our construction of the operative model of Numeracy was based on the paradigmatic socio-cultural studies such as Scribner (1984); Lave (1988); and Nunes, Schliemann and Carraher (1993); on conceptions of functional literacy such as OECD (2000); and on the six “big mathematical ideas” presented and discussed by Steen (1990). As mentioned this model has been used and further developed as an analytical tool. During the development of PAE mathematics, inspiration was found in Bishop’s (1988) cross-cultural studies of mathematical components in everyday activity and mathematical activities such as counting, measuring, locating were added to the fourth dimension (skills and understanding) of the Numeracy model (see figure 4).



**Figure 4.** Four analytical dimensions of Numeracy (Wedege, 2004 p. 113; revised from figure 3 in Lindenskov and Wedege, 2001 p. 6).

In what follows, I use the term “Numeracy” (with a capital N) to refer to the concept of numeracy as defined in this operational model and “numeracy” (with a small n) to refer to the underlying conception of numeracy as defined above.

### **What mathematics do adults know?**

As shown by Johansen (2006), it is a basic conception in Lindenskov and Wedege’s research and developmental work that adults returning to basic mathematics education are competent people managing their jobs and daily lives and taking part in society. This is unlike those Danish politicians to whom the potential students in basic adult education are mainly defined as people lacking basic skills. In the political Discourse the target group of PAE mathematics was construed as a group of people being excluded from society (Johansen, 2005b). This construction fits in with the results of the international surveys. In the Norwegian report on Adult Literacy and Life skills (ALL) it is, for example, stated that a total of one third of the adult population’s “literacy skills are defined by international experts as inadequate when compared with what is required in today’s labour market and everyday life” (Henningesen, 2008, p. 75). However, when asked if they have the necessary proficiency in numeracy to meet the demands of their main job, then more than 95% of the adults in the survey actually agree that they do. This discrepancy is not treated seriously in the report and Henningesen questions if it is ethically defensible – on the basis of what she calls “dubious statistics” – to “narrate” big groups of adults in the labour market as excluded from society and lacking basic skills.

Johansen (2002c) adapted the results from Second International Adult Literacy Survey (SIALS) in Denmark in a report designed for the Ministry of Education to be an analysis of the target group for PAE. The idea was to draw the profile of the potential target group, which was estimated to be people on proficiency levels 1 and 2 in document and quantitative literacy. Johansen concluded that, according to this, not only 418,000 of the un- and semi-skilled workers were potential students but also 325,000 skilled workers. However, Johansen’s analysis also reveals some limitations in the validity of the survey as a basis for describing the target group of PAE. Firstly, she shows that the kind of numeracy skills being measured in SIALS are not consistent with the functional skills and understandings defined as numeracy in PAE. Secondly, her analysis of a series of the test items shows that it is not the calculation skills that are tested but rather the competences of interpreting and understanding different types of documents with different task contexts. Johansen (2004b) asks: How is it possible to assess adults’ functional numeracy skills? She compares the methods used in the International Adult Literacy Survey and in the national test of PAE mathematics using the four dimensions of Numeracy (context, media, intentions, skills and understandings). Johansen finds among other things that it is the adults’ knowledge of the task-context rather than their mathematical skills which is tested in the international survey.

This also exemplifies another problem in the international surveys. As demonstrated by Lave (1988), there is a difference between the ability to calculate in school and in everyday life. The mathematical competence required to solve formal mathematics exercises differs from the mathematics-containing competence required for solving practical tasks even though they might involve similar types of mathematical ideas and techniques. In a student survey at the AVT centres, Lindenskov (1998a) investigated

possible differences and came up with the result that the 108 semi-skilled students in the survey were, generally speaking, stronger in practical calculation with “artefacts” on the table than in the corresponding formal tasks. Findings from an Australian study of numeracy in the context of chemical spraying and handling demonstrate that mathematically straightforward skills become transformed into workplace numeracy competence, when the complexities associated with successful task completion as well as the supportive role of mediating artefacts and the workplace community of practice are taken into account (FitzSimons & Wedege, 2007).

In education research, the overall interest in studying adults’ mathematics *in* the workplace is mathematics education *for* the workplace – whether a general or a subjective approach is employed (Wedege, 2004). With a general approach, adults’ use of mathematics in the workplace has been investigated in international surveys like the International Adult Literacy Survey where respondents were asked to report how often they used mathematics defined as (1) measuring or estimating the size or weight of objects and (2) calculating costs, prices or budgets in their job (OECD, 2000). In a local survey at the Danish Adult Vocational Training Centres with 160 respondents (semi-skilled and skilled workers), 75% reported frequently counting (blanks or money), 73% calculating (+, -, x, ÷), and 61% measuring (length or thickness) (Lindenskov, 1998a). However, the design of these kinds of questionnaires with more specific questions about adults’ use of mathematics presumes some knowledge of mathematics-containing activities in the workplace and of the specific language – for example, a question about reading a “diagram” or a “graph” which in the workers’ discourse could be known as a “chart” (Evans, 2000).

Traditional survey and interview studies do not reveal mathematics at work because mathematics is hidden from the perception of the worker by artefacts (material tools, workplace procedures or organisational features) or hidden from the consciousness of the adults due to their self perception and/or conception of mathematics (Lindenskov, 1996; Wedege, 1999, 2002a & b; FitzSimons, 2002; Evans, 2000). When you ask the general question: ‘Do you use mathematics in your work?’ The answer is often ‘no’. But the answer might be ‘yes’ if you ask more specific questions based on knowledge about what is actually happening in the workplace – such as mixing liquids or concrete in the right proportion (Lindenskov, 1998).

It is an assumption in the research that numeracy as a cultural technique, like literacy, is a basic general qualification for the labour market (Wedege, 2000b, 2002b). Thus, it makes sense to talk about “adult numeracy in the labour market,” and the four questions and perspectives of Numeracy in figure 4 (where, what, why and how) might help in investigating the complexity. In the analytical concept of Numeracy, there is an inevitable tension between the subjective embeddedness (numeracy as a personal competence) and the general determination (numeracy as a general qualification).

In order to analyse and describe numeracy in the labour market, Wedege (2000) has investigated selected firms within four lines of industry: building and construction, the commercial and clerical area, the metal industry, and transport. The object was to identify and describe mathematics in semi-skilled job functions and to analyse how mathematics knowledge at work is interwoven with the workers’ competences. In processing the data, an observation form was used as an operational tool constructed on the basis of Numeracy (for methodology, see Wedege, 2004). One of the working hypotheses in this study was that there are systematic differences between mathematics (or numeracy) at the workplace and in mathematical instruction structured by task

completion. This statement was developed and documented on the basis of her own and others' research (Wedeg, 2000a, 2002b). At the workplace, the 'tasks' result from satisfactorily completing a working task where the numbers are to be found or constructed with the relevant units of measurement (e.g., hours; kg; mm) given. It is the working tasks and functions in a given technological context which control and structure the process, not the particular 'task' itself. Some of these tasks look like school tasks (the procedure is given in the work instruction) but the experienced worker has his/her own routines, methods of measurement, calculation and judgment. Circumstances in the production might cause deviations from the instruction or, for example, that the number of random samples in the quality control be raised or reduced. It is characteristic that tasks are solved in different ways and that different procedures and solutions might be satisfactory. In the workplace solving tasks is a joint matter: you have to collaborate, not compete. Solving tasks has always practical consequences: a product, a working plan, distribution of products, a price, etc.

### **Why do adults (not) learn mathematics?**

The viewpoint in the idea of lifelong learning demands a rupture with the limited conception of learning and knowledge. Individual and collective learning processes do not only take place as schooling within formal education; the focus has to be moved to learning in the workplace and in everyday life. In workplace studies, we have seen that adults develop to a great extent their mathematics-containing competences and qualifications through participation in communities of everyday practice (FitzSimons & Wedeg, 2007). Nevertheless, it appears that their beliefs about mathematics are primarily related to their school experiences, and mathematics is experienced by many adults as something that others can do, but that they themselves can neither do nor need (Wedeg, 2002a). There is an apparent contradiction between many adults' problematical relationships with mathematics in formal settings and their "mathematics-containing" competences in everyday life. Resistance is a well-known phenomena in adult education today, one which is experienced by adults as a field of tension between felt needs concerning what one wants to learn – or has to learn – and constraints. However, there is very little research done on the subject, and resistance is often explained purely as a lack of motivation and the symptom described as non-learning. In order to investigate adults' resistance to learning, Evans and Wedeg have taken into account this set of conflicts between the needs and constraints in adults' lives. They see people's resistance as interrelated with their motivation and their competence, and thus as containing the potential to be a crucial factor in all types of learning (Wedeg & Evans, 2006). Lindenskov relates the concept of resistance to Skovsmose's notion of foreground for learning mathematics. She places resistance in the context of a problematique on inclusion, where the individual is a subject with intentions and with beliefs about the actual and future situation. Here the actual relationship between individual and instruction is crucial. However, blocks to learning are placed in a problematique "on segregation and integration where the individual as an object has a learning past, which the teacher has to take into account while organizing the instruction" (Lindenskov 2006, p. 87, my translation).

It is obvious that two approaches are needed in research on adults learning mathematics: the general (society's requirements with regard to mathematical competences), and the subjective (adults' need for mathematical competences). Wedeg (1999) discusses the conditions under which mathematics has classically "operated" in

the realm of adult education and lifelong learning. Bourdieu's (1980) theory of habitus and Lave's (1993) theory of situated learning both break with sociological and psychological problematiques about socialisation and learning, respectively. They both aim at challenging the dichotomies of subject-object and actor-structure. Both are critical of phenomenology and structuralism while simultaneously having social relations as the focus of their subject areas. Bourdieu set himself the task of constructing a theory of action as social practice and Lave a theory of learning as an integral part of social practice. By adapting and analysing an interview with a 75 year old woman about mathematics in her life, Wedege illustrates and discusses, by using the two analytical concepts of "legitimate peripheral participation" and "habitus", their suitability for analysing adults' mathematics knowledge in different situation contexts. She claims that the concept of habitus, which was developed and belongs in a sociological problematique, can be imported into a didactic problematique about adults' learning mathematics together with the concept of situated learning.

Complexity is a characteristic of the problem field in mathematics education and gender is one of the dimensions that researchers have to decide upon. As stressed by Henningsen (2002, 2008), very few studies on adults and mathematics are designed with gender in the foreground. Gender is an important analytical dimension in the on-going work on people's motivation and resistance to learn mathematics (Wedege & Evans, 2006). But so far Evans and Wedege have not designed an empirical study with gender in the foreground. They have access to rich empirical data from 81 semi-structured interviews with the students (2/3 female and 1/3 male) from an English research project on adult students' reasons for learning mathematics. In this project, gender is in the background: none of the research questions are about gender. However, in a pilot case study on one of these students, Wedege (2008) has tried to bring gender viewpoints into a small part of this data using an analytical framework of structural, symbolic, personal and interactional gender.

### **Why teach mathematics to adults?**

Could one imagine that mathematics teaching and learning provide semi-skilled workers with the possibility to develop technological competences which may place them as subjects in relation to technology in their workplace? That is, to have a personal competence that changes inability to initiative and power. And, if the answer is in the affirmative, how should mathematics teaching and learning be organised? This was the basic research question in Wedege's doctoral work, which indirectly produced an answer to the so-called justification problem: why teach mathematics to adults in vocational training and education (Wedege, 1995; 2000a). In the doctoral work planned by Johansen, "Bildung" (Da: dannelse) was the key concept, and the purpose was "looking for the concept of Bildung in mathematics education of adults". This is reflected in some of her publications (Johansen, 2002a, 2002b, 2005b), where aspects of the concept of Bildung, which is central in Nordic education and educational research, are pinned down: Bildung can be associated with "forming" and "shaping" on the one hand and with an "ideal" on the other hand. The process, which can be individual and active or social and more passive, refers to people developing throughout a lifetime. The ideal for human development refers to the goal of forming or shaping; and a theory of Bildung is founded on a conception of humanity and society and it includes a concept of Bildung, and the means for reaching this Bildung". Johansen (2002b) confronts two ideals of active citizenship in democratic countries: one definition presented by Benn



(2001, p. 155) at the ALM7 conference in which “the key components of citizenship are civic engagement and public discourse”, and another definition given by the European Council in a political context in which “employability – the capacity to secure and keep employment” is seen as the core dimension of active citizenship (Commission of the European Communities, 2000 p. 5). The first definition focuses on communication and participation in society, locally as well as nationally. In the second definition, the council links active citizenship with employability and, hence, only includes the labour force.

As mentioned above, Johansen has used the concept of Bildung as a tool for exploring goals of teaching numeracy to adults who lack basic mathematical skills. For example, the concept of Bildung captures the importance of not separating goals from their ways of formation, i.e. product from process – or “what” from “how” –, in education. Her working hypothesis was that there exist in society different and conflicting reasons as to why adults, who lack basic mathematical skills, need to learn mathematics. These conflicting reasons are bound to different discourses about what mathematics education is, and to various assumptions about the benefits that adults can get out of it (Johansen, 2003, 2006). Her specific research interest was in the reasons for providing mathematics education to adults with a lack of basic skills. This issue is an aspect of justification problem: Johansen investigates the general reasons given by the system or society – global as well as local (Denmark and PAE). It is especially in reform periods that reasons for mathematics education are formulated explicitly and the adult education reform in Denmark, which included PAE, was her case study.

In her analysis, Johansen (2005b, 2006) distinguishes between a political discourse and a researcher/curriculum planner discourse and she demonstrates that the reasons constructed in the two discourses conflict in the constructions of the target group (who), of the output of education (what) and of “best practice” (how).

As argued by Johansen ‘why’ and ‘what’ are closely related in mathematics education. In a 2001 survey, the potential PAE teachers’ views of mathematics were studied (Henningsen & Wedege, 2003). The material was analysed using a combination of quantitative and qualitative methods. An interesting result in relation to the debate on citizenship and democracy was this: a factor analysis and an analysis of the raw scores both seemed to indicate that teachers with no specialised education in mathematics and teachers with students on the lowest level tend to see mathematics as closed and undemocratic as compared to teachers with specialised mathematics education and teachers with students on a higher level in mathematics. In the qualitative part of the survey, the descriptions of mathematics in the teachers’ essays centred on three different types of answers, which were tentatively denoted: *everyday mathematics*, *curriculum mathematics* and *mathematics in the world*. In accordance with the rhetoric of Danish basic adult education in mathematics, the majority of the teachers’ essays were in the first category of everyday mathematics.

## HOW TO TEACH IN ADULT MATHEMATICS EDUCATION

Research and developmental work in Adults Learning Mathematics is ultimately about how to teach mathematics to – or with adults – in a way that promotes their learning of mathematics. But, as we have seen, there are many rough workings before the result: “What mathematics” and “Why mathematics” are two of the value-laden questions that

we have to answer. Johansen (2005a, 2006) has argued that it is possible to locate three models for “best practice” in the Discourse of ALM and that these models are grounded in conceptions of Who and Why. In the European developmental project *Adults Learning Mathematics Across Borders* (ALMAB), the participants realised that they had to go for good practices in the plural:

Analysing and conceptualising country differences of developed ideas and methods is a two-edged sword. It is a risk that our engagement in co-operation and our common research for “best practice” (singular) (...), will narrow our view so we cannot perceive that there might be no best practice which is best for all countries and cultures. Even not for European countries, and even not for the four ALMAB countries [Belgium, Denmark, the Netherlands, Norway] (Lindenskov & Hermeler, 2003 p. 217).

In ALMAB, teachers and researchers were working together across borders and it is a hypothesis that adult mathematics education also has the potential to improve intercultural understanding, partly by understanding learning mathematics as cultural, and partly by understanding culture with mathematics as a means (Lindenskov, 2003a). Teachers and researchers also co-operated in the European follow up project *Mathematics in Action* (MIA) where they investigated commonalities across differences in adult mathematics education. MIA has partners from seven countries, and the aim is to support teachers in adult education in order to improve the quality of learning and teaching of mathematics in adult education and to raise success rates of adult learners, by widening learning opportunities (Groenestijn & Lindenskov, 2007).

The Danish studies in the project *Vocational Mathematics* provided pieces of information for an answer to the question of how to arrange mathematics-containing teaching in AVT so that it supports the students and gives them the opportunity to exploit their potential. These pieces, which have been subject to further development in PAE, can be characterized under the two main titles of “relevance” and “visibility” of mathematics:

- The mathematics teaching in AVT has to be *relevant* to the participants’ vocationally oriented needs for learning. Thus, the content has to be prioritised and arranged carefully in order to achieve the action-orientated aim of the education.
- Use of mathematical ideas and techniques has to be *visible* in AVT-teaching in a way that the students’ everyday competences for employing these ideas and techniques in the work (their numeracy) are made visible (Wedeg, 1998b/2007).

Four years later, the principles for organisation and content of PAE Mathematics were presented and discussed in the Teaching Guidelines written by Lindenskov together with a group of teachers and published by the Danish Ministry of Education (2002). In this publication, one may find the four basic assumptions concerning adults’ relationship with mathematics on which the course is built:

- Adults’ numeracy has great influence on their participation in education, working life and societal life and their personal organisation in everyday life. However, many adults are not aware of this.
- Adults learn better when the mathematics education is meaningful i.e. the content and the methods used are authentic and relevant.

- Many adults had bad/negative school experiences with mathematics. This might cause blocks when they return to learn mathematics. Adults' resistance towards learning is also a well known phenomenon.
- Adults learn in different ways. Thus they profit from different learning activities and materials.

In the Teaching Guidelines, the operational model of Numeracy is presented and discussed in relation to the teaching practice, and the term numeracy is used through the whole publication.

As stated in the Act of Preparatory Adult Education (PAE), the educational programme was evaluated in 2004 by the Danish Evaluation Institute (EVA). Numeracy is the aim of the mathematics course and the pivotal point of teacher education programme, which was compulsory. Nevertheless, neither teachers nor school leaders mentioned the word "numeracy" during the whole evaluation process. As someone involved in the development of the curriculum in 2000-2001 and in the evaluation of 2004-2005 as one of the five members of the evaluation group<sup>1</sup>, Wedege (2007) questions whether the model of Numeracy as described above was actually implemented in the teaching and learning practices of PAE-mathematics – she formulated this as the 'success' or 'failure' of Numeracy as a tool in adult mathematics education.

According to Mertens (2005, p. 49) "Evaluations are conducted on the merit and worth of programs in the public domain, which are themselves responses to prioritized individual and community needs that resulted from political decisions." Thus politics and science are inherently intertwined. Here, *worth* refers to the value of an object in relation to a purpose: Is what the programme does important? *Merit* refers to the excellence of an object as assessed by its intrinsic qualities or performance: How well does the programme perform?

The aim of EVA's (2005) evaluation was to evaluate the strong and weak points of PAE and to assess whether the implementation of the Danish act on preparatory adult education is living up to its purpose, that is, it was mainly to evaluate the worth of the programme. In relation to her reflections on success or failure, Wedege found the following results relevant: It appears that many students have benefitted greatly from the course, both personally and socially, and a number of them have used PAE as a springboard for further education. A general example was of adults now being able to help their children with their homework; and happy people saying that, after all, they were really able to learn mathematics. Although the word numeracy was not mentioned by the teachers during the evaluation process, Wedege was sure that many students further developed their numeracy as a result of PAE mathematics. The first statement of the famous *Math Anxiety Bill of Rights* is this: "I have the right to learn at my own pace and not feel put down or stupid if I'm slower than someone else" (Tobias, 1993, p. 226). A common remark from the students was that they felt on a level with the teachers; they were actually treated as competent adults. Hence, it seems that participation in PAE can open the door marked "mathematics" to people. On the one hand, the adults get at chance of changing their beliefs about mathematics and their self-perception in relation to mathematics and, on the other, they have the possibility of formally qualifying to continue their education.

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<sup>1</sup> EVA needed a Danish researcher with expertise within the area of adult mathematics education. Wedege's involvement in the development of PAE-mathematics and non-involvement in the implementation of the curriculum were assessed and they concluded that she was impartial.

The main purpose of the evaluation was to assess the worth of PAE, however, the report also contains results concerning the merit. For example, it is observed that, in general, PAE is characterised by dedicated teachers and managers capable of creating a successful environment for adult education in which the students feel safe and where teaching is based on the students' needs and qualifications (EVA, 2005). According to the evaluation group's opinion, the teachers in general are well qualified and capable of carrying out their teaching on the basis of the qualifications and needs of the individual students. However, among the mathematics teachers, there are many examples of this not being the case. Here are a few examples: In the curriculum it is required that concrete material (e.g. juice, rice, wood, fabric) should be one of the media used in combination with activities and mathematical operations or concepts. In a locker marked with the words "concrete material" in a well equipped classrooms, Wedege found only plastic gadgets normally used in children's mathematics classroom. When students spoke in general about mathematics they often used the terms "equation", "x" and "y", which were not in the curriculum. In the following statement, Wedege found another example of how the students' views of mathematics and their perception of mathematics had not changed: A woman who was fired after many years in the same job said: "For the last 32 years I have only worked in LEGO's design department. I cannot do any mathematics." It seems that to her mathematics is still "what I cannot do" (see Wedege, 2002a).

The purpose of the PAE evaluation was not to investigate whether the educational planners' ideas, concepts and design as manifested in the curriculum were being implemented in the teaching and learning practices of PAE mathematics. However, being an educational planner and researcher, not a politician, one of Wedege's personal interests was to assess the intrinsic qualities or performance of the education (merit), particularly the implementation of the operational model, Numeracy.

In her paper "Balancing the Unbalanceable", Sfard (2003) sees the USA NCTM Standards (2000) as a result of a serious and comprehensive attempt to teach "mathematics with a human face". However, she states: "Success of educational ideas, however, is never a simple function of the ideas themselves. There is no direct route from general curricular principles to successful instruction" (p. 354). The conclusion of Wedege's reflections is in keeping with this statement. In the case of PAE mathematics we do not deal with reform of an education programme already institutionalised. This was a new programme which replaced another in adult basic mathematics. However, the schools and the mathematics teachers were the same. If we look at the teachers' views of mathematics before the start of PAE mathematics, we may find a reason why nobody talked about numeracy during the whole evaluation procedure (both self evaluation and in interviews). In most teachers' conceptions, mathematics is associated with everyday mathematics (Henningsen & Wedege, 2003). Thus, one might expect that they do not find it necessary to use the term "numeracy" instead of "mathematics". At one of the Ministry's information meetings on PAE mathematics, a teacher whispered to a colleague: "We go to this meeting; we listen and we go home doing what we are used to doing." The new rhetoric was interpreted in ways that fitted with the current practices in adult mathematics education and resulted in little change.

With the focus on the worth of the new adult mathematics education, "success" may be the response to the initial question whether the working model of Numeracy was actually implemented in the teaching and learning practices. What PAE mathematics does is important: many students have benefitted greatly from this course. But, looking

at the merit of the new programme, the response may be “failure”. PAE mathematics does not perform according to the curriculum with a dynamic interplay between the activities, the data and media, and the mathematical concepts and operations.

## CONCLUSION

The starting point of ALM research and education is the subjective approach with a focus on the individual adult learner and her/his competences and needs. But we do not have to neglect the general approach on numeracy with requirements from society (democracy and labour market) and from mathematics in the adult and further education system. It is common among teachers and researchers in mathematics education to claim that mathematics is everywhere and thus important for all to learn. However, there has not been much research done to legitimate and to qualify this claim, which is almost like a creed. Nevertheless, according to the surveys, 25% of the Danish adult population is defined as having inadequate basic skills by “international experts”. We need a much grander scale of empirical research – into people’s everyday lives – combining the two viewpoints: social requirements and individual needs in order to respect and to provide possibilities for adults to further develop their important but unrecognized mathematical skills and knowledge.

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