Mathematics at work

Researching adults' mathematics-containing competences

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In the workplace, mathematics is integrated in three dimensions of technology – in technique and machinery, in work organisation and in human competences and qualifications. In the article, methodology in researching mathematics-containing competences is the focus. It is argued that the complexity in adults' mathematics at work has to be investigated in a borderland between mathematics education and adult education research, where the import and reconstruction of theories and concepts are important tasks. An operational methodology, based on a model for analysing numeracy, is presented. This methodology – by virtue of the conceptual development associated with it – has also been useful in teacher training.

– What kind of mathematics should we teach in this industrial operator course? asked the mathematics teacher.

– You know best as you are the mathematics teacher! answered the vocational teacher.

This dialogue comes from a vocationally oriented educational course with elements from both general adult education and adult vocational training. In Denmark, these two educational systems have been co-operating in cross-sectoral courses, during the last 15 years, to provide adult early school leavers with vocational qualifications. In these courses, mathematics is one of the two most widely taught general subjects. Danish is the other one.

Why teach mathematics in vocationally oriented adult education? In this industrial operator course, the educational planners were in no

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doubt, which is not really surprising. One of the fundamental reasons given for mathematics education refers to the labour market – not only in vocational training but also in general education. Mathematics education should provide students with qualifications for their working life and contribute to the technological and socio-economic development of society. (Niss, 1996; Jensen, Niss & Wedege, 1998; Blomhøj, 2001; Johansen, 2002). 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. Thus mathematical knowledge as such, referring to the formal disciplines, for example algebra and geometry, is seen as a key competence (Darrah, 1992). As a consequence, the isolation from context reduces the complexity of workplace competences (FitzSimons, 2002; Wedege, 2000a), and use of mathematical knowledge in workplace situation is seen as a simple question of knowledge transfer (Kanes, 1997).

This exemplifies two problems that the researchers agree upon (cf. Strässer & Zevenbergen, 1996; Bessot & Ridgway, 2000):

- Mathematics is integrated in the workplace activities and often hidden in technology.
- The so-called 'transfer' of mathematics between school and workplace – and vice versa – is not a straightforward affair.

What kind of mathematics should be taught for the workplace? What kind of mathematical knowledge are the students supposed to develop in a vocational training course qualifying for a specific job function? 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, I have defined (Wedege, 1995, 2000a) *technology* in the labour market as consisting of three elements – techniques, human competences and qualifications, and work organization – and their dynamic interrelations. *Techniques* 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 quality certification). *Work organization* is used to designate the way in which tasks, functions, responsibility, and competence are structured in the workplace. This element includes workplace procedures[1].

Mathematics-containing technology is technology where mathematics is an integrated but potentially identifiable part[2]. In order to investigate *mathematical knowledge* (in Danish: matematikviden) as an integral part of adults' competences and qualifications in technology, I use Skovsmose's analytical distinction between three types of knowledge – following the terminology of the research community of the Centre for Research in Learning Mathematics (1998)[3]:

1. Mathematical knowledge as such.
2. Technological knowledge [with respect to mathematics], which in this context is knowledge about how to build and how to use a mathematical model.
3. Reflective knowledge [with respect to mathematics], to be interpreted as a more general conceptual framework, or meta-knowledge, for discussing the nature of models and the criteria used in their constructions, applications and evaluations.

(Skovsmose, 1990, p.124)

Skovsmose bases the distinction between mathematical knowledge and technological knowledge, which I prefer to denote as *practical knowledge*, on a thesis stating that by learning mathematics you do not automatically learn how to use it. Or, in other words practical mathematical knowledge cannot be reduced to mathematical knowledge.

This article will not supply answers to the question as to what kind of mathematics adults should be taught for the workplace, but it will shed some light on the complexity of adults' mathematical knowledge in the workplace. It will also present some of the difficulties in research which proposes an operational methodology which appears useful in teacher education as well. ”Adults, mathematics and work” is a relatively new area for research in mathematics education (see FitzSimons et al., 1996; Strässer & Zevenbergen, 1996). In the Nordic countries we have only a few studies in ”adults and mathematics” (Alexandersson, 1985; Löthman, 1992; Wedege, 1995; Lindenskov, 1996; Gustafsson & Mouwitz, 2002) and in ”mathematics in the workplace” (Unenge, 1995; Wedege, 1995; Lindenskov, 1996; Bradal, 1999; Lindberg & Maerker, 2001). This article will mainly contain references to Danish research, which – in addition to the absolutely necessary international contact and inspiration – is based on important Nordic findings from research in adult education and in mathematics education in general.

Identity of the research domain

The subject area ”adults’ mathematics in and for the workplace” is being cultivated, research problems are formulated in a dialectic relationship with practice and the subject area is growing into a subject field. In the international research forum ”Adults Learning Mathematics” (ALM), we have debated the identity of our research domain at the annual conferences since 1997. An important question in the debate is this: Where is the research domain situated? (Wedege, Benn & Maasz, 1998; Coben 2000a). This isn’t 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.

I claim (Wedege, 2001) that ”adults’ mathematics in and for the workplace” is situated in the borderland between research in mathematics education and in adult education from where we import and reconstruct concepts, theories, methods and findings4. The construction or reconstruction of conceptual frameworks are important tasks in research. Lave’s theory of situated learning and Engeström’s theory of expansive learning are two examples of general theories that have been used and re-interpreted in studies of adults’ mathematics in work (Wedege, 1999; FitzSimons, 2002; Kanes, 2002; Magajna & Monaghan, 2003). In this domain, problems and findings from mathematics education research in general are life-giving. The following statement suggests that it also works the other way around: ”For the past 15 years, studies of adults’ behaviour in the workplace have had an important impact on the way we think about mathematical reasoning” (Noss, Hoyles & Pozzi, 2000, p. 17).

Research in adult education and in mathematics education

The subject area *adult education* 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 is 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” (Christiansen & Walter, 1986). Which means that the subject area is 'always-already' structured and delimited by the concrete forms of practice and knowledge that are currently regarded as mathematics teaching, mathematics learning and mathematics knowing. However, a critical perspective might be opened up when studies concern the functions of mathematics education in society and in people's lives. (Wedege, 2000a). 'Critical mathematics education' is one of the forms this critique has found within mathematics education research (Skovsmose, 1994). 'Folk mathematics' is another form (Mellin-Olsen, 1987).

It is an important part of the self-conception in the research field of adult education that it cannot be subordinated in a disciplinary context (such as a sub-discipline in pedagogy, 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, linguistics, anthropology, philosophy). To create *inter-disciplinarity* the imported conceptual frameworks have to be derived and modified (Brousseau, 1986). 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).

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). In my definition of mathematics-containing technology, I talk about identifying integrated mathematics and it might be asked: identified or recognized by whom? When you ask an adult who doesn't have an explicit mathematics-containing profession, if he or she uses mathematics in the daily work, the answer is most likely to be 'no' (Harris, 1991; Bessot & Ridgway, 2000; Wedege, 2000a). To identify mathematics in the workplace technology might be a very demanding task. However, the person who is supposed to do it is a mathematician (teacher or researcher in mathematics education). This is also why we have to make explicit what we mean by mathematical knowledge.

In Danish adult education research and development, in the late 1980s and the 1990s, the theoretical construction of a general qualification concept was a driving force as adult education is closely connected with work as an individual and a social phenomenon (Olesen, 1994). Today the term 'competence' is almost hegemonic in educational discourses. In order to study the relation between vocational mathematics education and mathematics at work, I have (Wedege, 1995) imported and reconstructed the concept of qualification, in which a dualism is incorporated – qualification is seen both as a characteristic of the requirements for skills and abilities of the job function and as a characteristic of the skills and abilities of the (potentially) working person. After reconnaissance in adult mathematics education research, I have claimed that two different lines of approach are possible *and* necessary: *the objective approach* (the labour market's requirements with regard to mathematical knowledge), and *the subjective approach* (adults' need for mathematical knowledge in their present and future workplace) (Wedege, 1998, 2000a).

With the definition of mathematics-containing technology given above, this dualism is incorporated in and, at the same time, offered as a conceptual framework for reflection on the relation between technology and education (Wedege, 2000a). In importing 'qualification' from the Danish adult education research and re-defining the concept, we have a perspective grounded on a research interest in this conflict:

> 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 mathematics education research, two of the most recently published workplace studies illustrate this conflict between the objective and subjective perspectives as well as the combination of practical and reflective mathematical knowledge. In a large project (22 case studies), the research questions are about employers' demands for mathematical qualifications, competencies and skills (objective approach) and about what skills and competencies the employees felt were needed for the job, and what they currently possessed (subjective approach) (Hoyles et al., 2002). In a small project (a case study of a group of six technicians) practitioners' advanced mathematical thinking in a technological workplace is studied from a subjective perspective (Magajna & Monaghan, 2003).

In a large project conducted in 1995–97 by the Australian Association of Mathematics Teachers (AAMT) and involving school mathematics teachers at all levels, a third perspective – *mathematical approach* – was employed. The aim was to develop a set of rich descriptions of people operating in the workplace (about 40 stories) and the research question was "How are mathematical ideas and techniques used in practical situations" (Hogan, 1997). However, Kanes points to an implicit essentialist bias in the project's description of mathematical knowledge (Kanes, 1997).

Research in the workplace: difficulties

In education research, the overall interest in studying adults' mathematics *in* the workplace is mathematics education *for* the workplace – whether an objective or a subjective approach is employed.

From an objective perspective, adults' use of mathematics in the workplace has been investigated in local and national surveys and international surveys such as the International Adult Literacy Survey (IALS).

In IALS, 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. Between 30 and 50 per cent of the population in different countries reported engaging in one or both of the two numeracy tasks at least once a week. In the occupational group of skilled workers 49 to 78 per cent reported using measurement (1); in the group of service workers 33 to 67 per cent reported using calculations (2) at least once a week (OECD, 1995).

In a local survey at the Danish Adult Vocational Training Centres with 160 respondents (semi-skilled and skilled workers), 75 per cent reported frequently counting (blanks or money), 73 per cent reported calculating (+, –, x, :) and 61 per cent 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 e.g. a question about reading a ”diagram” or a ”graph” which in the workers' discourse could be a ”chart” (Evans, 1999, p. 38).

Traditional survey and interview studies don't reveal mathematics at work because mathematics is hidden from the perception of the worker by artefacts (material tools, workplace procedures or organisational features) (Strässer, 2002) or hidden from the consciousness of the adults due to their self-perception and/or conception of mathematics (Lindenskov, 1996; Wedege, 1999, 2002a, 2002b; Coben, 2000b; 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, 1998a).

However, getting access to a workplace as a researcher is not easy. Before you start the study, negotiating access to the workplace can be a complicated and complex process. According to Zevenbergen, there is always a ”gatekeeper” who must give his or her consent before you start, as in any ethnographic project. This can be the secretary who allows you access to the employer, it may be the manager, the union delegates and so on. Due to the hierarchical structure within a workplace this may be further complicated and multiple gatekeepers have to be confronted in order to gain access (Zevenbergen, 2000).

I have investigated semi-skilled job functions in selected firms within four lines of industry: building and construction, the commercial and clerical area, the metal industry, and transport. This investigation was carried out in a project for the Danish Adult Vocational Training System. The employers' and employees' associations helped me gain access to the workplaces and to find a relevant contact person, who was also representative of the firm. Two years later, in a mathematics teacher training course the participants were instructed to use the same methodology as described below to make observations in the workplace. This visit of 25 teachers into 11 different firms was organised by a local networking group.

It is important to find a contact person who can provide key information about the technology on the workplace and to contact key personnel. It is important to have a set of clearly articulated research questions that can be understood by the gatekeepers and practitioners. It is also important to have a clear idea of what will be asked of and offered to the participants. In order to illustrate these, I have used the contract shown in Figure 1.

Finally it is important to have an idea of what might be the potential problem areas in the process. Within the workplace setting, there are a number of identified areas of concern that are unique to this context and research. Many of these problems are union issues associated with salary, piecework contracts and job security (Zevenbergen, 2000).

It is a general trend in the labour market that semi-skilled workers now assume planning functions that previously were management tasks (Wedege, 2000a; Hoyles et al. 2002). The story shown in Figure 2 is constructed from authentic materials and situations, drawn from my observations of two different job functions, in order to illustrate that attitudes to mathematics are just as much part of a worker's qualifications as mathematical knowledge itself (cf. Evans, 2000). The story also illustrates that both practical and reflective mathematical knowledge is required of the worker when production is organized in autonomous groups.

I have chosen to present the story about Thomas here because my handling of it illustrates the specific kind of difficulties that you meet in workplace studies. According to the contract (see Figure 1) I sent this part of my report to the contact persons (representatives of the firms) as well. Two days later, one of them called me to ask if Thomas was one of their employees: the company didn't want people with his attitude. This

Contract with employer (firm)
/ employee (worker)

It is agreed that

- the researcher observe the employee during half a working day
- the employee is interviewed at the end of the working day
- the employee will answer some supplementary questions from the researcher if needed

The researcher's report from observation and interview will be send to the employee for comments.
All information concerning the firm reported by the researcher will be sent to the contact person for comments. He/she will also approve photos and materials collected.
After this the collected data can be used in research concerning mathematics at the workplace at Roskilde University

Firms and employees will be anonymous in the reports.

Signed by

Date Copy to employer/ employee

Figure 1. *Example of contract between firm, worker and researcher.*

response underlines the importance of maintaining strictly ethical approaches to research, especially when it can affect people's livelihoods[5].

Methodology: importance of the context

Context is a central issue in mathematics education research. However, it is important to distinguish between two meanings of the term 'context' when reflecting on and planning mathematics education in adult vocational training. I have suggested a terminological clarification: context representing reality in tasks, word problems, examples, textbooks, and teaching materials (e.g. Christiansen & Walter, 1986; Unenge, 1995) is named *task context*. In this sense the term is often normatively employed,

Thomas is a CNC operative in an autonomous production group at a metal company. There is no job rotation at the lathe he operates and this suits him very well. When he is checking the objects that are turned, he reads a graph (or a 'chart' as he would probably say, cf. Evans, 1999) on the screen where he evaluates whether the finished object fulfils tolerance requirements. He can also see whether production is stable, which can have implications for the tools and the number of objects to be checked.

There is a graph on the notice board of the production groups showing the sickness statistics of the group. The graph also compares average absence due to illness for the department and for the company as a whole. This absence is up over 8% in Thomas' group while the average is below 4% in the month of October. During the break Thomas speaks with the other members of his group. He says: "That was me. That month in hospital. You can see it." A long term of illness for one person affects the average. The group as a whole understands this but it is of no interest to Thomas how the figures are calculated or the graph constructed. Actually, his attitude is that all these statistics are something the management sit doing in the office because they do not have anything else to do.

There are graphs showing the service grades of each of the groups on a joint notice board in the department. At the end of November Thomas' group is 45 hours behind. The service grade is down to 80. The production leader suggests that they should organise the work in shifts so that they can come up to 100 during December and not work between Christmas and New Year. Thomas takes no part in the conversation of the group about organising the work so that the service grade can be maintained, and he has no intention of doing so. He just knows that it is a matter of working hard.

(Wedege, 2000c, p. 204)

Figure 2. *Story about a semi-skilled worker with no sense of mathematics.*

e.g. in curriculum documents as a requirement that teaching and materials shall contain 'real-life context' or 'meaningful and authentic contexts'. The other meaning has to do with historical, social, psychological etc. matters and relations, when researchers in mathematics education speak of a context for learning, using and knowing mathematics (school, everyday life, place of work, etc.), or context of mathematics education (educational system, educational policies, etc.) (e.g. Christiansen & Walter, 1986; Mellin-Olsen, 1987; Harris, 1991; Niss, 1994; Strässer & Zevenbergen, 1996; Llorente, 2000). I call this type *situation context* (Wedege, 1999).

An illustration of the two terms, task context and situation context, is to be found, for example, in a Swedish empirical study of the school as context for thought, which also demonstrates how the meaning of a task context (e.g. stamping a letter) changes with the situational context (in a mathematics or a social studies classroom) (Säljö & Wyndhamn, 1993).

Outside the school settings, the meaning of mathematical activities also changes depending on the different situation contexts. In a workplace it could be a matter of life and death. As a female operator in quality control in an electronics firm said to me: "There is a difference between making a mistake in an aeroplane and a radio. – Agreed?" (Wedege, 2000a, p. 132)

In Lindenskov and Wedege's general definition of numeracy, the situation context is an important dimension. We describe *numeracy* (in Danish: numeralitet) as an everyday competence – in terms of functional mathematical skills and understanding – that, in principle, all people need to have in any given society at any given time. In our definition, numeracy is thus historically and culturally determined and it changes along with social change and technological development: numeracy in Denmark 2003 might be different from numeracy in Togo 1973. In order to capture some of the complexity of numeracy in society, we have given 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 adult mathematics education and research (Lindenskov, 1998a&b; Wedege, 1998, 2000a; Lindenskov and Wedege, 2001; Johansen, in press).

In order to analyse and describe numeracy in the labour market, I have investigated selected firms as mentioned above. My object was to identify and describe mathematics in semi-skilled job functions and to analyse how mathematical knowledge at work is interwoven with specific qualifications and social qualifications.

Observation form

Part one

(*Context*)

Trade – Working function – AVT course

Firm – Address – Contact person (name, tel.)

Date and time of the observation

Researcher's name – Employee (name, tel.)

Part two

(*Data and media*)

Numbers, figures, formula etc. observed at the workplace

+/– (are they used or not in the job function)

* (is the material collected)

Kind of material

Part three

Chronological notes from the observation in three dimensions:

1) *Media* (written/oral material and information; concrete material or process)

2) *Personal intention* (to have/give information, to gather data, to control, to assess)

3) *Skills and understanding* (handling and sense of quantity and numbers, dimension and form, patterns and relations, data and chance, change, and mathematical modelling)

Figure 3. *Observation form from workplace studies* (Wedege, 2000a).

I have collected three types of data: observation, interview and collection of artefacts. To be more specific I shadowed a core worker for half a day to describe the action taking place. At the end of the day I interviewed the worker to explore any issues that had arisen. Then I wrote up these observations as a descriptive story with examples of particularly interesting incidents, which I call *episodes*[6]. Furthermore, I photographed interesting situations and tools and collected written materials with figures, formulas, diagrams etc. (such as working drawings, plans and statistics). In processing the data I used the observation form as an operational tool constructed on the basis of the numeracy mentioned above (see Figure 3).

It is an assumption in my research that numeracy – just like literacy – is a basic general qualification in the labour market. (Wedege, 2000a, 2002a). Thus it does make sense to talk about *adult numeracy in the labour market* and the four questions and perspectives in Figure 4 (where, what, why and how) might help in investigating the complexity.

In the analytical concept of adult numeracy in the labour market there is an inevitable tension between the subjective embedding (numeracy as a personal competence) and the objective determination (numeracy as a general qualification).

Conclusion: adults' mathematics in and for work.

The title of this article is "Mathematics at work" with the double meaning of mathematics in the workplace and working mathematics (i.e. mathematics having an effect)[7]. With the optic of a mathematician (researcher or teacher) we recognize 'mathematics at work' in all three dimensions of the workplace technology: integrated in technique, embedded in work organization, and incorporated in human qualifications

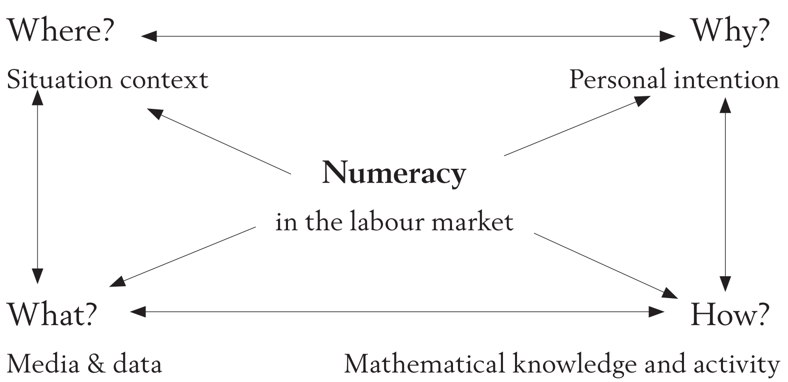

Figure 4. *Four analytical dimensions of numeracy on the labour market.*

and competences. But we cannot make the deduction from mathematics at work to mathematics education for the work. The translation from qualifications in the workplace into qualification in school and vice versa is not straightforward. From written material collected in the workplace (work sheets/instructions, description of machinery etc.), it is possible to generate a long series of mathematical problems, with the workplace as task context, but without observations of adults' mathematics in the workplace context (how is the work organized – how does a competent worker solve this problem) the use of authentic material might be just a pretext for teaching mathematics. In adult education, this misuse can be counterproductive and cause resistance in the learning process among the students (Wedege, 1995; Lindenskov, 1996).

In general, mathematics teachers in vocationally directed education have a serious handicap. They teach mathematics with the aim of qualifying students for working life although they themselves are likely to have never left the school settings. It is necessary to distinguish mathematical knowledge as a specific qualification for a specific job function and mathematical knowledge in numeracy as a basic general qualification on the labour market (Wedege, 2002a). The mathematics teacher, in the dialogue opening this article, didn't know per se which mathematics was relevant to qualify for an industrial operator work function, e.g. in the quality control – even if or when the vocational teacher gave her the written documentation from the workplace. The 25 adult education teachers each visited one of 11 different firms using an appropriate methodology to observe competent workers, and it was possible, with only half a day in the workplace settings, to learn something about adults' mathematics at work. On the basis of our terminological clarifications and with use of the observation form as an analytical tool it has become possible to make visible some of the mathematics integrated and some of the complexity of the context. An incident related by a French colleague, Corinne Hahn, illustrates that neither the mathematics teachers nor the management have tools to answer the question about which mathematics should be taught in order to qualify for a specific job in industry: A multi-national company asked the industrial school to make courses with a specific mathematical content. It didn't work. The workers did not qualify as intended. Now, researchers from the school make workplace studies before planning the mathematics course. And it does work!

In fact three of the teachers from the course mentioned above visited the same company in Denmark, where they used our methodology to observe three semi-skilled workers. The workers were so-called "key persons" with different job functions (quality control, bottling and storekeeping). Before the visit, the contact person had stated that there was no numerical calculation in the single working function, and that the only handling of figures was reading and transferring from the computer to a paper form. Nevertheless, in a *situation context* of a workplace, with requirements of efficiency and quality in the production and when the *personal intention* included planning and coordinating production and transport, it became evident that the job functions involved *mathematical knowledge and activities* (e.g. handling percentage and proportions, sorting, comparing, converting) and various types of *data and media* (e.g. time, codes of many digits, liquid, bottles, labels, forms on computers and paper).

What do we learn from the workplace studies? Our research questions are crucial. In my research, as well as the teachers' investigations, the starting point has been the subjective approach of investigating competent workers' mathematics. This contrasts with the usual objective approach of asking what mathematics do incompetent workers lack. However, when we research the human element of mathematics-containing technology on the labour market, both concepts – competence and qualification – and the dialectic relationship between them should be taken seriously: on the one hand society's requirement to adults' qualifications (e.g as illustrated in the story in Figure 2) and on the other hand adults' mathematics-containing competences in the workplace context. When lifelong mathematics education becomes a structuring principle in the educational system, this will be even more important.

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Notes

1 The word "technology" is very often used just for the hardware in information and communication technology alone; it would be tempting to replace the term and redefine it in a conceptual framework of "artefacts" and "instruments" (cf. Strässer, 2002).

2 This term "mathematics-containing" is imported from German, translated into Danish and now into English. With the German term 'mathematikhaltigen Weiterbildung', Jungwirth, Maasz and Schlöglmann (1995) paved the way for research on vocationally-oriented adult education where mathematics is an integral part. They invented the term but the definition is mine (Wedege, 2000a).

3 The "Trinity" of "in", "with" and "about" science and mathematics formed the basis of science education at Roskilde University in the 1970s (Niss, 2001).

4 In the book "What counts as mathematics?", FitzSimons is seeing 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." (FitzSimons, 2002, p.2).

5 The reaction from this contact person could also be read as a comment on the authenticity of the story: he actually recognizes "Thomas" in the story as an operator from metal industry.

6 In organizing my investigation, I have followed the systematics developed in the AAMT project, but I apply another theoretical framework and the investigation is based on another conception of mathematics.

7 Like the term *mathematics at work*, the concept of *mathematics in action*, defined by Skovsmose (2001), has a double meaning: mathematics operating as part of technological planning and decisions processes, and mathematics as part of technology itself. On one hand Skovsmose's concept is broader (concerning technology in general, not only work). On the other hand it is more specific (concerning only technological planning and decisions, not routine production).

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Sammendrag

Matematik er integreret i teknologiens tre dimensioner på arbejdspladsen: i teknik/maskineri, arbejdsorganisering og menneskelige kompetencer/kvalifikationer. I denne artikel er fokus på metodologi for undersøgelser af disse matematikholdige kompetencer. Der argumenteres for at kompleksiteten i voksnes matematik i arbejde skal undersøges i et grænseland mellem matematikkens didaktik og forskning i voksenuddannelse, hvor import og rekonstruktion af teorier og begreber er vigtige opgaver. Desuden præsenteres en operationel metodologi, baseret på en arbejdsmodel for numeralitet, som netop i kraft af begrebsudviklingen har vist sig også at være nyttig i læreruddannelse.