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Construing Mathematics-Containing Activities in Adults' Workplace Competences: Analysis of Institutional and Multimodal Aspects

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Abstract

In this paper we propose and discuss a framework for analysing adults' work competences while construing mathematics-containing "themes" in two workplace settings: road haulage and nursing. The data consist of videos and transcribed interviews from the work of two lorry-loaders, and a nurses' aide at an orthopaedic department. In the analysis we adopt a multimodal approach where all forms of communicative resources (e.g., body, speech, tools, symbols) are taken into account. We also incorporate the institutional norms of workplace activities into the analysis. We coordinate a multimodal social-semiotic perspective with a learning design sequence model (Selander, 2008) which makes explicit the institutional framing. Adopting this framework enables us to understand learning as communication within a domain, with an emphasis on content matters, interpersonal aspects, and roles of communicative resources and artefacts. We describe a tentative theme (Measuring: precision through function and time), and illuminate how workplace specific resources for measuring provide efficiency and function.

Keywords: workplace, mathematics, competence, multimodality, learning, institutional norms, interpersonal

Introduction

An overarching aim of the project to which this paper is connected is to analyse and understand adults' mathematics-containing work competences (Wedege, 2013). In doing this we want to investigate how we can learn from the workplace without taking assumptions of school mathematics for granted. In subsequent investigations and papers we will relate these findings to vocational education and general schooling. In this paper we propose and discuss an analytical framework for analysing mathematics-containing activities in adults' work

competences where different functions of multimodal communication and institutional aspects are addressed. Two situations from our data, both video collected, will serve as a starting point for the article. We briefly describe them then address them later in the article.

In one situation, we followed two lorry-loaders when they loaded a trailer. As will be shown later on, one essential resource in this task was the loading pallets on which most of the goods were positioned. We will describe how we can identify measuring in the work performed by these lorry-loaders and how our analytical framework helps us to broaden our understanding of the mathematics-containing activity. In another situation we visited a nurses' aide at an orthopaedic department. Her main responsibility was to put plaster cast on injured limbs. Measuring was also identified here and was elaborated using the framework.

Research on and approaches to workplace mathematics

In the literature concerning workplace mathematics we have distinguished a number of themes that are particularly relevant to us. They are described here and we pay extra attention to research in relation to measuring. In addition, different possible approaches for research in this field are described.

Mathematics in the workplace

Research on mathematical practices in the workplace has been carried out since at least the beginning of the 1980s: For example, the Cockcroft report (1982) which initiated several other studies.

Research on workplace mathematics has been described as a field which has passed through different phases (Bessot & Ridgway, 2000; FitzSimons, 2002, 2013; Hoyles, Noss, Kent, & Bakker, 2010; Wedege, 2010a). In the early years researchers presumed that mathematics was easily observable and visible in workplace activities, and frequently such studies resulted in (long) lists of mathematical contents described in "school mathematics" terms (Fitzgerald, 1976). Many of these studies have been criticized for having been conducted with, what has been described as a *mathematical lens* (Zevenbergen & Zevenbergen, 2009) or *mathematical gaze* (Dowling, 1996, 1998), or with a far too narrow conception of mathematics/numeracy (Harris, 1991; Noss, 1998).

Seminal works on the use of mathematics in informal workplace or everyday settings during the 1980s and 1990s draw attention to, for example, differences in strategies and cognitive structures between "school mathematics" and "out-of-school mathematics" and to the fact that schooled and un-schooled individuals perform and succeed differently in everyday and workplace practices as compared to school contexts (Lave, 1988; Nunes, Schliemann, & Carraher, 1993).

Research on workplace mathematics has, during recent years, been dominated by socio-cultural perspectives. Increasingly sensitive theoretical and methodological tools have been used to reveal the complexity of mathematical practices at work. One finding is the fact that mathematics in work is often hidden in activity, culture, social practice, and artefacts. This has been used to explain why it is so difficult to classify these mathematical practices in school-mathematical terms and, when so classified, how the complex use of mathematics in workplaces is reduced to simple computations, measurements, and arithmetic (Gustafsson & Mouwitz, 2008; Hoyles, Noss, & Pozzi, 2001; Keogh, Maguire, & O'Donoghue, 2010).

Mathematics as activity: The example of measuring

Bishop (1988) identified six pan-cultural activities which can be characterized as mathematical activities. These are: counting. locating, measuring, designing, playing, and explaining. In this paper, we focus mainly on measuring which, according to Bishop, is concerned with "comparing, with ordering, and with quantifying qualities which are of value and importance" (p. 34).

We are looking at practices which include measuring in a broad sense. Measuring is central in mathematical activities in people's everyday lives and in workplace practices in all cultures. Several studies have shown the importance of measuring in different occupations (for an overview see, e.g., Baxter et al., 2006). Among these are studies on carpenters, carpet layers, nurses, process- and manufacturing industry workers, and so forth. Other more recent examples are Bakker, Wijers, Jonker, and Akkerman (2011) who write about the use, nature, and purposes of measurement in workplaces; a study of process improvement in manufacturing industry (Kent, Bakker, Hoyles, & Noss, 2011); a study of boat-building (Zevenbergen & Zevenbergen, 2009); and a study of telecommunication technicians (Triantafillou & Potari, 2010).

Measuring is closely linked to estimating, and the boundaries between these activities are not obvious. Adams and Harrel (2010) have, as part of a more extensive study, presented observations and interviews from four occupations, and concluded that experienced workers often replace measuring with estimation. One important conclusion is that estimation is a complex activity that is learned by experience, and is based on a different rationality from conventional school-methods for measurement which may focus on units and calculations (at least in secondary school). In this article we will use the term *measuring* linking to the concept of activity (i.e. doing) rather than the generic label *measurement*, to address the human activity of measuring. We also include estimating in the concept of measuring.

Adopting a subjective approach when researching adults' competence

In the literature on mathematics in the workplace, two approaches can be identified (Wedege, 2013). In the subjective approach, the interest lies in mathematics as part of personal needs and professional competences in working communities and in various situations. In the general approach, the interest lies in societal demands or demands made from the perspective of school mathematics. Drawing on Bernstein's (2000) pedagogical models, performance and competence, Wedege (2013) also identifies professional competence as construed from the workplace rather than taking school mathematics as a starting point. In the research described here, we draw on the subjective approach when we strive towards capturing the mathematics-containing activities within workers' competences. In this article we present a tentative finding of what could be called a *theme* in professional competence within the sectors of nursing/caring and vehicle/transport. Adopting our analytical framework from this article, we are able to construe wider themes between activities in two sectors of work. These themes will in subsequent research and papers be connected to a general approach when we compare our findings to the demands made within school.

In this article, we draw on the notion of competence. Ellström (1992) describes competence as an individual's readiness for action with respect to a certain task, situation or context. Wedege (2001) concurs and opposes a view of competence as consisting of "objective" competencies defined as being independent of individuals and situations. According to Wedege (2001), competence is:

- always linked to a subject (person or institution)

- a readiness for action and thought and/or an authorisation for action based on knowledge, know-how and attitudes/feelings (dispositions)
- a result of learning or development processes both in everyday practice and education
- always linked to a specific situation context (p. 27).

The term *competence* can be further understood from two perspectives: (a) formal competence in terms of authorisation; for example, that a person has adequate education for a given position; and (b) real competence in terms of whether a person will really be able to demonstrate the abilities that are identified; for example in a particular certification (Wedege, 2001; 2003). In terms of our research interest here, the second meaning is more relevant.

Addressing the socio-political through the notion of institutional framing

We position this paper in a socio-political paradigm – paradigm is here understood according to Lerman (2006) – in mathematics education. This is connected to sociology and critical theories (Valero & Zevenbergen, 2004; see also Ernest, Greer, & Sriraman (Eds.), 2009). Mathematics incorporates means for understanding, building, or changing a society (Mellin-Olsen, 1987). Skovsmose (2005) acknowledges this (see also Jablonka, 2003; Gellert & Jablonka, 2009), whilst also stressing that mathematics does not hold any intrinsic good; instead mathematics can be used for different purposes in society and people's lives. Thus, there is a need to address the role of the use of mathematics in society and in this article we incorporate institutional aspects of workers' mathematics-containing activities.

We view the institutional context as always present. An early example of a theoretical discussion of this is given by Popkewitz (1988), who considers institutional framings as one way to address social and critical aspects in studies of school mathematics (see also Mellin-Olsen, 1987). Also, in work-places the institutional context and societal dimensions are always present (e.g., Salling Olesen, 2008). Here are included dominant discourses, the use of artefacts developed over time, the division of time, established routines, workplace structures, and authoritative rules (Selander, 2008, drawing on Douglas, 1986). A similar view is described by Bishop (1988, p. 36) when he writes about the development of units, and systems of units: "there is a clear progression, with the main idea being that of the stronger the environmental and social need the more detailed, systematic and accurate the measure". As we will show in our analysis and findings, what constitutes an accurate measuring unit may be quite different in the workplace from what is usually emphasised in school.

Institutional aspects were addressed by Wedege (2010b) when she proposed the concept of *sociomathematics*. She described sociomathematics as both a subject field combining mathematics, people, and society, and a research field. We are also inspired by FitzSimons and Wedege (2007) who adopted Bernstein's (2000) concept of horizontal and vertical discourses (see also FitzSimons, Mlcek, Hull, & Wright, 2005). Bernstein refers *Vertical discourse* to knowledge within a discipline, such as academic mathematics. This knowledge is coherent and systematic; the *horizontal discourse* refers to contextual knowledge and a relevant example for us is the context bound mathematics used and developed in the workplace. In the study by FitzSimons et. al (2005), activity theory (Engeström, 2001) was adopted as a theoretical framework, and the main findings were 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" (p. 49).

Analytical framework

In this section we present our analytical framework where a theory of communication – multimodal social semiotics (e.g., Van Leeuwen, 2005) – is coordinated with a model of a learning design sequence. Design is here understood in a broad sense, for example including both aesthetic and functional aspects. The term *coordinate* implies that the two theoretical approaches are compatible with respect to underlying assumptions (Prediger, Bikner-Ahsbahs, & Arzarello, 2008).

Learning as multimodal communication

In this article we attempt to problematise learning in order to avoid the term learning becoming a black box (Ellström, 2010). Ellström refers to the term, black box, to learning as it is in studies on innovations in workplaces. Learning is here described as a key concept, but it is not really spelled out how it is operationalised in the studies. We view learning as closely connected to human activity and understood as meaning-making towards an increased communication in the world through the communicative resources of a discipline (Selander & Kress, 2010; see also Björklund Boistrup, 2010). Learning in a work-place constitutes, at least in part the competence that the worker gains over time. This competence is not something fixed, but changes and may evolve over time. In operationalising learning, we discuss knowing that is part of workplace activities, and hence the worker's competence, rather than discussing learning as such. By using the term knowing instead of knowledge we want make clear that we do not take into account an objective knowledge "out there" to be learnt. Instead, knowing is viewed as constructed and construed in communication among humans throughout history (Foucault, 2002; see also, e.g., Delandshere, 2002; Valero, 2004b, Volmink, 1994). What valid knowing is and how it is demonstrated in communication is not set in stone. At different times throughout history, the perception of what qualifies as important knowing has changed and will continue to do so.

In this article we draw on a multimodal approach when we adopt social semiotics as part of an analytical framework (Van Leeuwen, 2005). In a multimodal approach, described by Selander (2008; see also Björklund Boistrup & Selander, 2009), all modes of communication are recognised. Communication in a multimodal perspective is not understood in the same way as communication in a narrow linguistic perspective, focussing on verbal interaction only. Rather, all kinds of modes are taken into consideration, such as gestures, and gazes, pictorial elements and moving images, sound, and the like. Modes are socially and culturally designed in different processes of meaning-making, so that their meaning changes over time. It is also the case that "content" in one kind of configuration (e.g., as a measure on a dip stick), will not necessarily be exactly the same content in another configuration (e.g., as a number on a device for filling the oil):

> Different representations of the world are not the "same" in terms of content. Rather, different aspects are foregrounded. In verbal texts we read linearly, within a time frame, whilst a drawing will be read within a space frame. And a graph does not represent a knowledge domain in the same way as numbers does [sic]. The modes that are "chosen" in a specific situation reflect the interest of the sign maker, and they are therefore not arbitrary. (Björklund Boistrup & Selander, 2009, p. 1566)

We argue for the importance of understanding multimodal communication to be able to fully understand a phenomenon such as mathematics knowing and learning in a workplace. In social semiotics, three meta-functions are often operationalized in analysis (Halliday, 2004). Halliday focused mainly on written and spoken language in his work but in this article, drawing on Van

Leeuwen (2005), we adopt the meta-functions in connection with a multimodal approach. These meta-functions are: the ideational, the interpersonal, and the textual. In Morgan (2006), these functions are used with a focus on the construction of the nature of school mathematics activity. In this article, we start out with the meta-functions as used by Kress et.al. (2001; see also Björklund Boistrup & Selander, 2009). The *ideational* meta-function is related to human experience and representations of the world (Halliday, 2004). Here there is a possibility to address the content, the "what-question" of a communication. In this article we look for measuring activities and resources in lorry-loaders' and nurses aides' practices and competences. The *interpersonal* meta-function is about how language (used in a broad sense in this article) enacts "our personal and social relationships with the other people around us" (Halliday, 2004, p 29). In this article we examine the roles of measuring activities for and in relations between the people involved. The *textual* meta-function is related to the construction of a "text" and this refers to the formation of whole entities (Halliday, 2004). With a multimodal approach, the term *text* refers to multimodal ensembles which are communicatively meaningful and part of the overall pattern of the actual communication. Here we are interested in what roles resources and communicative modes play in the measuring activity.

A model for understanding learning in other-than-school contexts

We draw on a model where a multimodal approach is connected to an institutional framing (Selander, 2008; Selander & Kress, 2010): a design theoretical perspective of learning.

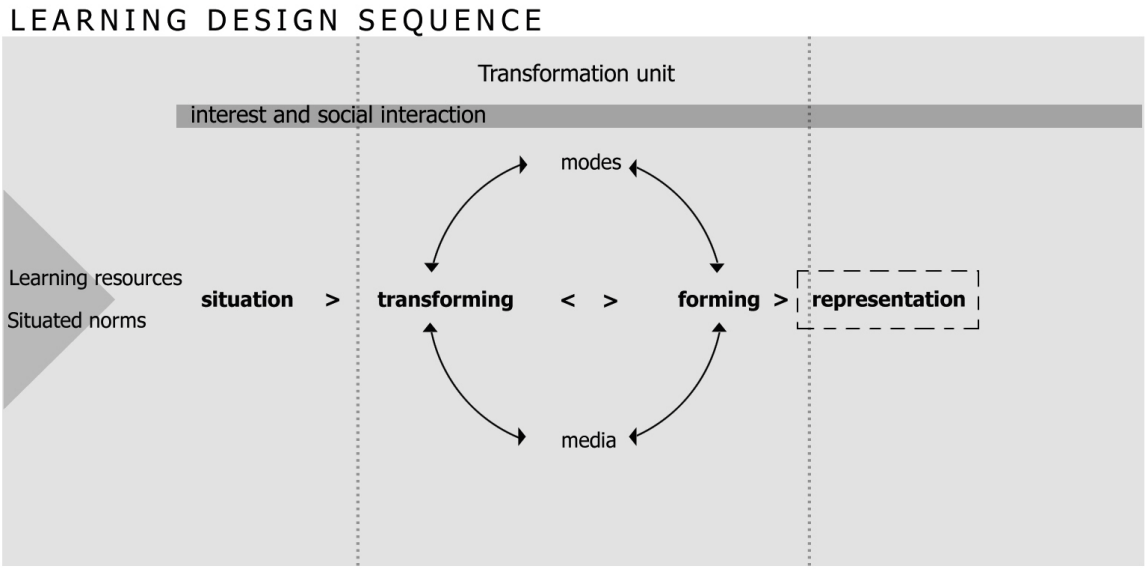

Figure 1. A learning design sequence (Selander, 2008, p. 16).

This first model (Figure 1) gives the general principles for how communication, learning, and knowing can be addressed without starting from the perspective of a school setting, but considering meaning-making and learning as something always present. The starting point, the "situation", is here to be taken as any other-than-school setting, for example a workplace. The worker and his/her work are embedded in a social practice with different kinds of social norms and with different semiotic resources at hand. The duration of the process that the model

captures can be rather short (seconds) but also longer (like hours or days). Selander (2008) writes:

> In many instances we are put in situations where we try to figure out the challenge and what standpoint and action that is meaningful. It could be situations where we ask ourselves if the bus ticket still is of value or if we can swap a book, for example given as a present, for another one in the book store. In each such micro situation we also learn something about what is usual or "proper", about restrictions and regulations etc. And there are also moments of creativity when we try out different solutions. (p. 14-15)

It could be possible to use this general learning design sequence to analyse what a person is doing at work. A person who is performing a well-known task is now and then met by an explicit learning purpose while working. It may be a situation where an innovation of some kind is needed in order to facilitate the work (Ellström, 2010). Even more explicit is the learning purpose when the person is new at her/his job. Even though the model by Selander (2008) is relevant for a study of learning and knowing mathematics at a workplace, we find the next model more suitable for our purpose. The reason for this is that we, as the research team, change the situation when we are present, and even more when we pose questions during the filming of the activity. The model that we use as our analytical frame is the Semi-Formal Learning Design Sequence.

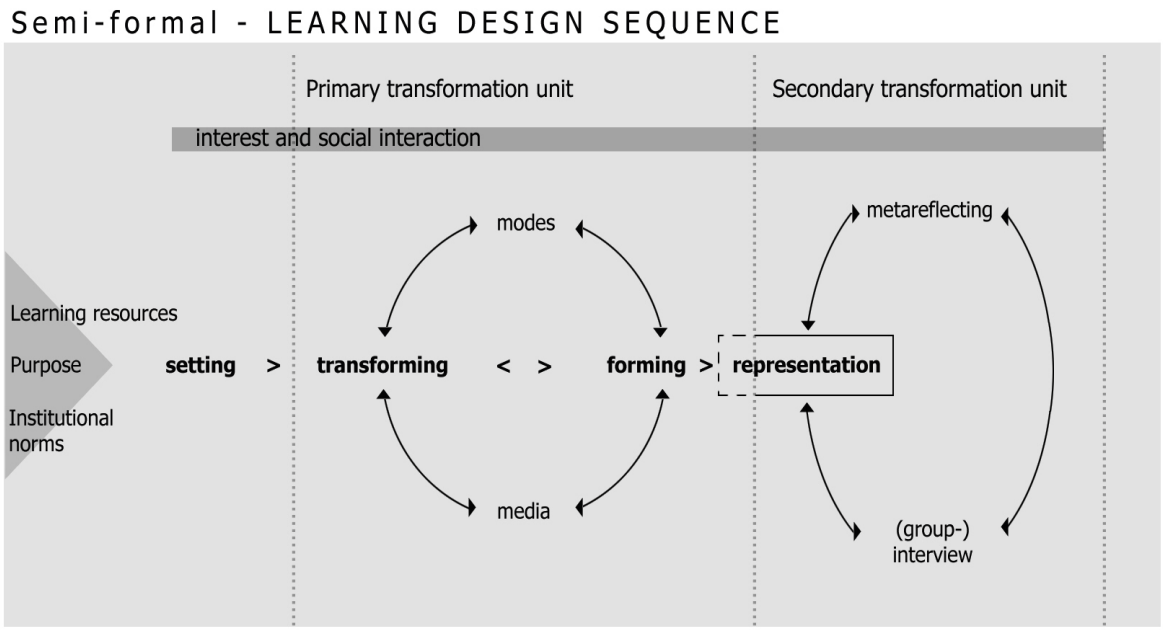

Figure 2. A learning design sequence – semi-formal (Selander, 2008, p. 17)

The idea behind the semi-formal learning sequence in Figure 2, is that the starting point is a *setting* (not a *situation*, as before) where the learner is confronted by an articulated learning purpose. In our case it is mainly the workplace that constitutes the setting where there are institutional norms affecting what is taking place and what is counted as relevant knowing. When we as researchers pose questions (see below for a description of our interviews), the worker is invited to meta-reflect on her/his work. There are then transformations taking place when the worker communicates through her/his actions, engaging with different artefacts, and then describes and explains the working process through speech and gesture, and so forth. In this sense both the primary transformation unit – the actual work – and the secondary

transformation unit – answering our questions and showing us the tools and processes of the work – are going on at the same time.

Methodology

The research design of the qualitative study for which this article is written is a case study. When using the term *case study*, we draw on Yin's definition (1989):

> A case study is an empirical inquiry that:
>
> - investigates a contemporary phenomenon within its real-life context, when
> - the boundaries between phenomenon and context are not clearly evident, and in which
> - multiple sources of evidence are used (p. 23)

The phenomenon we are interested in here is to learn more about mathematics within the work and competences of lorry-loaders and nurses' aides. More specifically we are interested in how we can analyse the complexity of mathematics interwoven in work. Our data gathering methods consist of:

- *Videos* which were filmed at one or two visits at each work-place. We followed one worker (or two), who was doing her/his regular work, with a hand held camera for about one hour. As a back-up, we also recorded sound with additional sound recorders. In total we visited six work-places, three in each sector.
- *Apprenticeship interviews* which were performed when possible during the filming. With apprenticeship interviews we mean that we took the role of a person trying to learn the work processes that the worker was engaged in. We then posed curious questions to the worker during her/his work.
- *Photographs* which were taken during our visits with a special focus on signs, notices, artefacts, etc.
- *Interviews* which were performed after the first visit at the workplace. These have so far been performed by Maria C Johansson as part of her PhD process (Johansson, 2013; in preparation). We used excerpts from these interviews to inform our understanding of the video data.

This article is based on data from two workplaces: one road-haulage company and a plaster unit at an orthopaedic department of a hospital.

Analysis and example of findings: measuring activities

The analytical framework that we present in this article is connected to the subjective approach mentioned earlier (Wedege, 2012). Here we pay attention to adults' work competences and the activities we can construe as being possible to connect with mathematics. Our emphasis is on learning/communication in a workplace setting and we view workers' actions as communication, as well as learning and knowing.

In the following, we utilise the analytical framework of the three meta-functions outlined above (ideational, interpersonal, textual) to describe the measuring activities as part of lorry-loaders' work competence and of nurses' aides' work competence. The kind of measuring that we focus on in this analysis is what Bishop (1988, p. 34) labels "quantifying qualities which are of value and importance." We also use the Learning Design Sequence model above, in how we

view the presence of the institutional framing. The three meta-functions are actually interwoven and it is an analytical construction to tease them apart. This may, in a systematic and structured way, bring forth findings that we otherwise would not capture. This also causes the same "events" to turn up more than once in the analysis, but with different emphasis.

Lorry-loaders

At the road-carrier company, we visited lorry-loaders, one of whose tasks was to load trailers according to specifications provided in written forms. The form was developed by administrative staff in the office. While we were there, one trailer was loaded using forklifts, and in discussions we were told about the written loading form (see Figure 3) which specified, for example, the number of pallets, the weights of the goods, the companies' names for delivery (these names have been deleted in the photograph), and where different pallets were intended to be unloaded. In the first excerpt, the two lorry-loaders are talking with two persons from the research project before they start to load one trailer. One of them, Con (pseudonym), describes how they decide whether to load the trailer in one or two layers (Excerpt 1). The transcripts are made multimodally. In Excerpt 1, we identify Time, Speech (what people say and how they say it), Body (what people do including resources and artefacts), and Gaze (where people look).

Time	Speech	Body	Gaze
03:11	*The ideal is that you can get it [the trailer] fully loaded. But for*	Nods now and then.	Looks at research staff.
	this trailer we load now,	Points at trailer.	
	well, we, I, have seen the		
	loading form before.	Two hands 20 cm apart [marking the top and bottom of form].	
	Det optimala är ju att man kan få den fullastad. Men som denna trailern vi lastar nu. Så har vi, jag, sett lastlistan innan.*		
03:21	*Then I know that we can load it*		Looks at research team.
	without the dual goods. Dual goods	Moves hands up and down.	
	means two pallets on top of one another.	Right hand above left hand with a distance in between.	
	Då vet jag att vi kan lasta den utan att dubbla godset. Dubbla gods det är två pallar på varandra.*		
03:27	*Then we utilize the*		
	whole space to make the safest solution possible.	Moves flat hands from center and out [indicating a surface]	
	Då utnyttjar vi hela utrymmet för att göra en så säker lösning som möjligt.*		

Excerpt 1. Lorry loader describing the loading of a trailer. *Speech in Swedish.

Later on, when the workers started loading, the use of the pallets becomes clearer. Each pallet was positioned "horizontally" in the trailer. In this case there is room for two pallets beside each other along the trailer's width. If instead they were positioned vertically there was room for three. This was also explained in a communication after the trailer was finished loading. Con explained how the size of the pallets, 800 mm x 1200 mm, makes this possible. In Figure 3 the pallets in the trailer are shown and it is also possible to get a glimpse of the loading form that Con describes and shows with his hands early in Excerpt 1.

Figure 3. Images from the road-carrier company.

In the following, we describe our analysis where we operationalise the social semiotic meta-functions and where we also coordinate with the learning design sequence by Selander (2008). The concepts from the Learning Design Sequence (Figure 2) are in italics and the analysis is mainly organised through the meta-functions.

- Ideational meta-function: We analysed the data from the lorry-loaders, looking for human experiences and representations of the world (the content, the what-question) in relation to the measuring we could construe. We then construed a measuring activity in the *institutionally* framed *setting* where the lorry-loaders used the loading pallets (i.e. *resources*) as measuring units for the actual goods to be carried. Here the workers did not use the measuring means and units normally used in school, such as using a measuring tape to find out the two lengths in centimetres, and then calculate the area.
- Interpersonal meta-function: When analysing the data from the lorry-loaders for personal and social relationships, we were able to capture how the informal measuring activity via the pallets entailed their involvement in the process on behalf of the

customer, and also gave a certain amount of control to the loaders. Our assumption is that the use of pallets as measuring resources saves time, which in the end lowers the cost for the customer. This may be seen as one *purpose* with the use of the pallets. The pallets were also communicative *resources* for the two lorry-loaders who, almost without any talking, communicated on how to position the pallets on the trailer when carrying them on the forklifts. When Con told the research team about his work we could identify engagement and an *interest* in making clear what he meant and generally in his work. This analysis is based on his speech and the many gestures. During this *meta-reflection* there were many *transformations* between speech and gestures.

- Textual meta-function: When looking at the multimodal text that was communicated to us as visitors through actions, speech, gestures, etc., we analysed the roles of, in this case, the informal measuring activity through the *resources* of the pallets. Our finding is that the pallets took the role of facilitating the measuring, as they provided a measuring function in themselves as well as a means for efficiency and effectiveness. Another *resource*, the written form, made the measuring activity visible for people involved. As shown in Excerpt 1, we could identify how there are *transformations* between different communicative *modes* which also *forms* the activity. One *transformation* goes from the written loading form to the loading process. This *transformation* concerns both *media* (from written form to physical activity) and *modes* (from writing in words and symbols to speech, body movements, and gaze). During the loading, Con ticks off the things that are loaded, an activity which constitutes a new *transformation.*
- *Institutional norms*: The loading form is normally used at this workplace and *formed* the situation. In this workplace, its use is a long-standing tradition. The pallets are standardised according to the transport sector regulations.

Nurses' aide (plastering)

In the orthopaedic department of a hospital, we visited a nurses' aid who specialised in plastering. During our visit, she put plaster on an arm and hand of a patient who had an injury to his thumb. In this situation we were mainly silent and the chat was between the nurses' aide and the patient. For this example we have chosen only to present pictures. In Figure 4 some details from the room where it took place are shown. It is also possible to see how the nurses' aide rolls out dry plaster wrap on the arm. The analysis mainly is focused on this action.

Figure 4. Images from the orthopaedic department.

In the following we describe our analysis of measuring activity from the work performed by this nurses' aide. Similar to the previous section, the concepts from the learning design sequence (Selander, 2008) are in italics and the analysis is mainly organised through the social semiotic meta-functions.

- Ideational meta-function: We were able to construe a measuring activity where the *setting* was a room that was *designed* for plastering. There were boxes with different kinds of plaster stored on shelves and there were appropriate tools present (*resources*). Prior to the actual plastering process, the nurses' aide measured up with the dry plaster wrap directly on the patient's arm. The aide then used the first measuring as a unit and made repeated folds based on this unit before finally adhering it to the patient's arm. The *resource* for measuring here is the plaster itself.
- Interpersonal meta-function: This plastering activity is very important with respect to the patient (in the healing process). Measuring directly on the arm may then be the most accurate. It should also look neat and tidy (caring about the patient). The nurses' aide described the procedure of plastering to the patient as she worked. This also seemed to act as a calming function and simultaneously gave her an opportunity for *meta-reflection* on her activity. Here we could identify *interest* and *interaction.*
- Textual meta-function: The plaster has several roles here. The main function was to stabilise the arm and hand during the healing process. Moreover, it fulfilled a measuring function, and its correlation to the length of the arm was part of the function. The *transformations* took place both during the *primary* and *secondary transformation unit.* In the *primary transformation unit*, one example is where a specific distance on the arm was *transformed* from the body to the plaster (*resource*) by the nurses' aide when she measured up. This unit was then *transformed* to a longer piece of plaster during the repeated folds. In the *secondary transformation unit*, there were *transformations* from *modes* such as body and artefacts into speech when the nurses' aide explained the process to the patient.
- *Institutional norms*: Methods for plastering are *designed* together at this workplace. Some may be general between hospitals, and some are specific to this work-place. Speed is important: Another patient is waiting, but the long-term function for this patient is the highest priority.

A general theme of measuring activity: Precision through function and time

Here we connect the two cases described above and we construe a general measuring activity between the two sectors of vehicle and transport, and of nursing and caring, which we expect to be found in many workplaces within these sectors.

Ideational. This measuring activity is an alternative to school-traditional precision measuring with tools. The worker uses "rough" measuring units. At a first glance it seems like function, result, and/or time is superior to precision. At a second glance we interpret that the accurate precision for the loading process or healing process is accomplished *through* this workplace specific measuring activity. "Rough" in this case does not contradict that the method is well adapted to the situation and that accuracy is judged by the situational needs and constraints/restrictions."

Interpersonal. In this activity we captured relationships between the worker and the workplace and (in) directly the customer (company or patient). Ethical considerations are that it is important to do a good job so that the customer is satisfied. This could, for example, include economic considerations such as not to spend too much time which would increase the cost and decrease the profit. Interpersonal aspects also concern what the employer may impose on the workers (a good job, customer satisfaction, expediency). Also aesthetic aspects, such as "looking neat and tidy", are part of what is regarded as a good job and what may make the customer satisfied.

Textual. The workplace specific resources for measuring provided efficiency and functionality. Resources can then have the role of facilitating the work; for example, the task is completed more quickly through the use of "rough" measuring units. When a measuring needs to be recorded, appropriate documents are included.

Institutional. Resources contribute to standardisation within the workplace, as well as between workplaces. Written forms can take this role as well as other resources for measuring. Notions concerning a "good job" also concern the institutional framing. The client is thus part of the institutional framing.

Concluding discussion

As stated previously we position this article within a social and critical paradigm. For our work, this quote by Valero and Zevenbergen (2004) is particularly relevant:

> In mathematics education it is always possible to ask whose knowledge is being represented in society, schools and classrooms, and with what effects for the different participants in it. The recognition of the different and multiple positions that social actors can adopt in relation to and with the use of (school) mathematical knowledge is at the core of discussions of equity, social justice and democracy in mathematics education. (p. 2)

They continue by arguing that such social aspects are essential to an understanding of mathematics education practices in broader institutional contexts (see also Valero, 2004a). At the same time, such aspects form this broader understanding of the *social*. In terms of research on mathematics-containing activities in workplaces, our standpoint is that such an understanding incorporates an interest in whose and what kind of knowing is represented in school mathematics, and also how this is connected to the broader social context. We know from earlier research (Fahrmeier, 1984; Lave, 1988; Masingila, Davidenko, & Prus-Wisniowska, 1996; Nunes Carraher, Carraher, & Schliemann, 1985; Nunes, et al., 1993; Scribner, 1985) that the mathematics that can be construed from workplace activities has connections to, but is not the same as, school mathematics. One way to put it is that workers' voices are missing in the school context, often also in prevocational studies.

The complexities of the workplace could be brought into school mathematics if we want to represent also the knowing of workers in different sectors. This is described by Steen (2003) in this way:

> The contrast between these two perspectives—mathematics in school versus mathematics at work—is especially striking (Forman and Steen 1999). **Mathematics in the workplace makes sophisticated use of elementary mathematics rather than, as in the classroom, elementary use of sophisticated mathematics.** Work-related mathematics is rich in data, interspersed with conjecture, dependent on technology, and tied to useful applications. Work contexts often require multi-step solutions to open-ended problems, a high degree of accuracy, and proper regard for required tolerances. None of these features is found in typical classroom exercises (p. 55; our emphasis).

What we have accomplished through utilising our analytical framework, based on a multimodal approach and a design theoretical approach, is to connect the people, the workers and their competence, to the workplace, and to the institutional framing. The three meta-functions have served the purpose of connecting the content (ideational) – the measuring, with relations between the people involved (interpersonal), with a special attention to the roles of resources (textual). The model by Selander (2008; see also Selander & Kress, 2010) helped us understand the institutional framing, and also the different kinds of communications that took place when we, on one hand, observed the work-processes, and, on the other hand, posed questions about it. What became clear to us in the analysis is what measuring accurately (Bishop, 1988) may mean in a workplace context, for example that precision for the loading process or healing process was accomplished *through* workplace-specific measuring units.

We would argue that our research is part of a development of research methods and analytical frameworks sensitive enough to do justice to the complexity and to the power of mathematical practices other than school-mathematics, for example, in workplaces. Included here is a view of the worker as self-governed and competent (Wedege, 2001) as well as an approach that there is much to learn from workplaces that can be brought into vocational education and training (VET) settings. This article is consequently an example of a study within what Wedege (2010b) labels as sociomathematics: "a research field where problems concerning the relationships between people, mathematics and society are identified, formulated and studied" (p. 452).

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