ASSESSMENT IN THE MATHEMATICS CLASSROOM. STUDIES OF INTERACTION BETWEEN TEACHER AND PUPIL USING A MULTIMODAL APPROACH

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Several researchers stress the fact that students focus their learning according to the content in the assessment and to how this is carried out. Assessment in this particular study is not in a "usual" formal situation. Instead it refers to assessment which can be found in the interaction between teacher and pupil during hands-on work in mathematics. The analytical tools are derived from research of formative assessment, the National syllabus in mathematics and a multimodal approach within a social semiotic frame. The results indicate that pupils do not always get constructive feedback when showing meaning-making in mathematics. Possible reasons for this are discussed from an institutional perspective.

BACKGROUND AND RESEARCH FOCUS

In this paper assessment is considered as a concept with broad boundaries and by this there is assessment going on, explicit or implicit, during every lesson in mathematics. Examples of what can be part of assessment are diagnoses that teachers give to pupils, documentation such as portfolios, feedback in classroom work etc. When a teacher approaches pupils who are working on mathematical tasks, parts of the teacher's communication with the pupils are based on some kind of assessment. In this paper the focus is on the feedback processes between teacher and pupil. I also, finally, discuss possible explanations for the teachers' actions in this particular case from an institutional perspective.

What is assessed and how the assessment is carried out influence pupils' learning (see e.g. Black & Wiliam, 1998; Gipps, 1994). Black & Wiliam (1998) analysed several (250) studies, all which have formative assessment in focus. Many of the studies show, among other things, that it is important that pupils get feedback on what qualities their performances show and also on what they should focus their learning on in the near future. The studies that Black & Wiliam have analysed rely on quantitative methods. In fact, they stress the importance of qualitative studies for the field of assessment. The lesson with hands-on work, described in this study, is part of a project in which the teachers and researchers worked collaboratively to explore possible meanings of qualities of knowledge/abilities the pupils are expected to develop according to the national mathematics curriculum. In this particular project the teachers worked in pairs performing lessons which were planned by the teachers and researchers i collaboration. The pupils in the study are 10 years old.

The purpose of this study is to find out more about the assessment that takes place in a classroom during experimental work about measurement and volume. The research questions are (The words in italics are described on p 3-4):

A. What is the mathematical focus of the interaction in relation to the feedback processes during the hands-on work of measurement and volume? – *Ideational meaning*.
B. What different (communication) modes do the teachers show (or not show) acknowledgement of in the feedback during the interaction with the pupils? – *Textual meaning.*
C. What kind of feedback is taking place between teachers and pupils during the work within a mathematical frame? – *Interpersonal meaning*.

FRAMEWORK – FORMATIVE ASSESSMENT, GOALS AND MULTIMODALITY

The basis for this study is: (1) research of formative assessment with the importance of feedback (Black & Wiliam, 1998) as discussed above; (2) "goals to aim for" in the national curriculum in mathematics (Swedish National Agency for Education, 2001), because the teachers in the project were supposed to let these goals inform classroom work; and (3) a multimodal approach within social semiotics, mainly how it is described by Kress et al. (2001).

Goals to aim for

There are a total of 14 "goals to aim for" in the national curriculum. The goals that are most relevant to this study are:

> The school in its teaching of mathematics should aim to ensure that students
>
> - develop an interest in mathematics, as well as confidence in their own thinking and their own ability to learn and use mathematics in different situations
> - appreciate the value of and use mathematical forms of expression
>
> The aim should also be that students develop their numerical and spatial understanding, as well as their ability to understand and use:
>
> - different methods, measuring systems and instruments to compare, estimate and determine the size of important orders of magnitude (Swedish National Agency for Education, 2001, p 23-24).

A multimodal approach

This multimodal approach emphasizes that learning can be seen in a social semiotic frame and that communication is considered not only from a linguistic perspective; instead all modes of communication are recognised. Modes can be, for example, speech, writing, gestures and pictures. Each mode has its "affordances" in relation to the specific situation and people engaged in a communication (Kress et al., 2001),

that is which mode is “chosen” in a specific situation is not arbitrary; instead it is the best way for this person to communicate in this particular moment.

From a social semiotic perspective there are three kinds of meaning that all communication is understood to reflect; ideational, textual and interpersonal. In Morgan (2006) these functions are used with a focus on linguistics and on the construction of the nature of school mathematical activity. The origin of the three functions is from Halliday but in this paper I am using them with a focus on multimodality according to Kress et al. (2001) and with a focus on assessment in mathematics. *Ideational* meaning can reflect what is going on in the world. *Textual* meaning refers to formation of whole entities which are communicatively meaningful and *interpersonal* meaning’s focus is on interactions and relations between people. Another feature for this multimodal approach is *signs of meaning-making*. The feature of meaning-making provides, as I see it, possibilities for assessment. Even though a pupil’s answer is mathematically incorrect it can be a sign of meaning-making. According to this a teacher does not have to give feedback to a pupil that an answer is incorrect, but instead (s)he can see the opportunity to look at the answer as a starting point for a mathematical exploration. That is, an answer which is “wrong” according to the mathematical discourse can still be seen as a sign of meaning-making of a pupil, and by this as a part of the learning process.

In mathematics education the issue of different forms of representation is not new and in research in mathematics use of different modes is necessary. Often mathematics researchers choose symbols to express mathematical ideas, but use of figurative expressions as in graphs is also quite common, and one can also find written text in comments. However, for some pupils the typical “language” used in mathematics can be one (of several) obstacle to overcome. Lennerstad (2002), Høines (2001) and many others claim that an important issue in mathematics education is to overcome these obstacles by using many forms of representation when teaching mathematics. For assessment in mathematics in Sweden there has been some focus on different forms of representation/expression. One example is a material for formative assessment in mathematics, Assessment Scheme for Analysis of Mathematics (distributed in year 2000 by the National Agency of Education), in which teachers are encouraged to capture their pupils’ knowledge in different forms of expression: actions, figures, words, symbols. (Skolverket, 2000b).

ANALYTICAL TOOLS

Following Kress I believe that important aspects of assessment in the interaction are possible to reveal using this multimodal approach.

The *ideational meaning* contributes to the analyses of the mathematical content in the interaction. The content that I am looking for can be derived from the goal about “different methods, measuring systems and instruments to compare, estimate and determine the size of important orders of magnitude”. I look for what *signs of*

meaning-making the pupils show in mathematics, especially measurement and volume. I also look for what signs of pupils' meaning-making the teachers (do not) reflect in their feedback. These aspects constitute the analytical base for answering the question about the mathematical focus of the feedback.

Different modes have different "affordances" in interaction according to this multimodal approach. How the modes are used in the interaction is a part of the *textual meaning*. This goes well with the goal to "appreciate the value of and use mathematical forms of expression" (Swedish National Agency for Education, 2001). Still, this seems a little too narrow for this study and this goal is therefore combined with the quote under the headline Assessment in Mathematics: "An important aspect of the knowing is the pupil's ability to express her/his thoughts verbally and in written text with help from the mathematical symbol language and with support from concrete material and pictures" (Skolverket, 2001a). These aspects constitute the analytical base for answering the question about what different (communication) modes the teachers show acknowledgement of in the feedback.

Interpersonal meaning is part of what I look for when dealing with the issue of feedback in general. This fits well with the goal concerned with "develop[ing] an interest in mathematics, as well as confidence in their own thinking and their own ability to learn and use mathematics in different situations" (Swedish National Agency for Education, 2001). In some of the studies referred to in Black & Wiliam (1998) there is evidence that feedback to a pupil on the knowledge she/he has shown in certain tasks has impact on interest and self confidence, whereas feedback on what has to be learned has impact on the learning. As I choose to see it in this study there is some kind of feedback between teachers and pupils taking place every time there is an interaction between them. Pupils are working with a task and the teacher comes by and whether the teacher says something or not she is monitoring the pupils work and makes some kind of assessment. In different modes the teacher shows signs of assessment and the pupils can react to this feedback in different ways. These aspects constitute the analytical base for answering the question about what kind of feedback is taking place between teachers and pupils during the work within a mathematical frame.

METHOD – VIDEO RECORDING

The focus of the data collection is on the interaction between the teachers and the work performed by one group in the class. One video camera is fixed on the group most of the time. The group also has a portable voice recorder on the table.

For the analysis I choose the parts of the films, where the teachers and pupils interact within a mathematical frame and each of these parts are recognized as an "episode". I make multimodal transcriptions of the episodes. Methods for this are described in Rostvall & West (2005) and Kress et al. (2001). I write what each person says – pupils in one column and teachers in another. I also describe their gestures, as well as

their body positions and gaze, in separate columns. The teachers are referred to as T1 and T2. The girls in the pupils' group are referred to as G1 and G2 and the boy as B. Example of transcript:

Time	Speech (Pupils)	Speech (Teachers)	Gestures (S)	Gestures (T)	Body and gaze (S)	Body and gaze (T)	Notes
	The lesson starts with a teacher introduction. The pupils are divided into different groups. Each group gets different measurement instruments, like measuring cups and scales. The group in this sequence got rulers and measuring-tapes.						
1:26	G1- This is two centimetres. This is two centimetres long		G1 holds one piece of pasta and shows it to the rest of the group. G2 puts her hands together.		G1 leans forward and looks first at the piece of pasta and then at the other girl in the group. G2 looks at G1. B looks around and then at the piece of pasta in G1's hand.		Episode 1 starts
1:29	B-Which one?		B is putting the measuring-tape in order.		B looks at the piece of pasta. G2 looks at G1		
1:31	G1-This		G1 takes the pasta piece in her hand and shows it again.		G1 and B look at the pasta. G2 looks at the sound recorder.		
1:33	B1-Is it two millimetres?		G1 puts the piece of pasta on the desk.	T1 has her hands on her hips.	G1 looks at B, then T1 and then at the piece of pasta.	T1 approaches the group and is standing in an upright position. Gaze in direction to the group table. Smiling?	

ANALYSES OF ONE EPISODE FROM THE LESSON

As mentioned in the transcript, the lesson starts with a teacher introduction. The pupils are divided into groups. Each group gets different measurement instruments, like measuring cups and scales. The group in this study gets rulers and measuring-tapes. All groups get pasta (penne) and they receive the task to use their instruments to figure out how much pasta they have got.

All analyses are discussed with and validated by two researchers and also by the two teachers in the study. The analysis of the ideational meaning focuses on what signs of meaning-making the pupils show when it comes to mathematics and how this is (not) reflected in the teachers' feedback. I also articulate which different modes the teachers show acknowledgement of; the textual meaning. The analysis of the interpersonal meaning focuses on to what extent the teacher give feedback. I do write down "all" feedback from the teachers that is not taking place, but this does not mean that my opinion is that this kind of feedback should take place at each occasion. I just want to make visible what is taking place and what is not, with respect to the feedback. For the transcriptions and analysis I have chosen episodes. Each episode starts just before any of the teachers arrive to the group and ends just after the teacher(s) leave(s) the group. In this paper I describe one episode thoroughly. The transcript is divided in parts and each part follows by a short description. After the episode I present an analysis of the episode.

Example of episode

Before this episode starts the pupils try for a while to find a way to use the rulers and measurement-tape. After some time they instead start to count the pieces of pasta:

Time	Speech (Pupils)	Speech (Teachers)	Gestures (S)	Gestures (T)	Body and gaze (S)	Body and gaze (T)
5:50	B-Shall I count?		B has the hands on the table holding on to some pieces of pasta.		G1 and G2 are looking at a girl from another group.	
5:55	G1-We are going to divide all in tens. Here are ten.		G1 shows the groups of tens that she has formed on the table. G2 moves one of the 10-groups in front of G1. Then puts her hands back to the pasta pieces in front of her self. B takes pieces of pasta one at the time and puts them in front of him.		G1 looks at the pasta groups in front of her on the table. G2 and B are looking at her/his hands	
5:59	"All three are counting"		The three pupils are counting groups of tens. Neither of them touches the measuring instruments.			

What we can see here is that the pupils have put the measuring instruments away and they work together putting the pasta into groups of tens. Soon one of the teachers approaches (T1 is standing partly in the way of the camera):

Time	Speech (Pupils)	Speech (Teachers)	Gestures (S)	Gestures (T)	Body and gaze (S)	Body and gaze (T)
6:15		T1-Hey. When you are doing like this, do you have any use for the things you got from T2?	G1 contiues counting.	T1 holds her hands together, then points at the table.	B and G1 are looking at the table.	T1 is standing in front of the table. T2 is standing beside her.
6:18	G2?-No					
6:20		T1-No, was it any point for you getting the things from T2 from the beginning? How could one use them?	G1 contiues counting.	T1 holds her hands in front of her.	B and G1 are looking at the table. G2 is looking at T1.	
	G1?-We don't know.			""		

In the beginning of the interaction two of the pupils do not look at the teacher. Instead they look at the table and on what they are doing with their hands. The teacher goes on pursuing the use of the measurement instruments:

Time	Speech (Pupils)	Speech (Teachers)	Gestures (S)	Gestures (T)	Body and gaze (S)	Body and gaze (T)
6:30		T1-When do you have use for this then?		T1 holds something from the table in her hand and shows it to the students.	G2 looks at T1. G1 looks at G2. B looks at T1's hands.	T1 looks at G2.
6:33	G2-When I am going to measure				G2 looks at T1. B looks at G2 and T1. G1 looks at T1.	T1 looks at G2. T2 leaves the group.
6:36		T1-What do you measure then?				
6:38	G2-The length of something					
6:42	B-Are we supposed to measure every piece of pasta?				B, G1 and G2 look at T1	T1 looks at the group.
6:43		T1-Do you think that they are about the same	T1 points at the pasta.			T1 looks at the group and at the pasta.
6:45	G1-These are two centimetres, this I have already measured		G1 holds a piece of pasta and shows it to T1.		G1 looks at T1 and the piece of pasta. B looks at the table and at T1.	T1 looks at the group.

The teacher tries to make the pupils to find a use for the measuring instruments. She asks them when they usually use these instruments. Finally she makes a suggestion:

Time	Speech (Pupils)	Speech (Teachers)	Gestures (S)	Gestures (T)	Body and gaze (S)	Body and gaze (T)
6:48		T1-Can you put them together, or? I believe that one of you was on to something like that before, who put them a little like this.		T1 puts pieces of pasta together.	All three lean forward and look at the pasta and the teacher's hands.	T1 looks at the pasta.
6:56	G1-I put hem like this beside a ruler		G1 takes a ruler and shows what she means in front of her on the table.		B looks at G1:s hands.	T1 looks at G1's hands.
6:57	B-Yes G1, this can hardly be two centimetres		B takes one piece of pasta in his hand and holds it up in front of him and G1. G1 continues her work on the table.	T1 holds her hands in front of her.	B looks at G1 and the piece of pasta.	T1 looks at B's hand.
7:00	G1-Don't interrupt, I put hem like this beside a ruler		G1 shows how she measured the piece of pasta. B is still holding his pasta piece in the air.		G1 is looking at what she is doing on the table. B is looking at his pasta piece and into the camera.	T1 is looking at the table.
7:06		T1-But try that then, but with this, take this, you place it here on the table		T1 takes a measuring tape in her hand.		T1 is looking at the measuring tape.
7:10	#-We have already done that					
	unhearable					T1 takes a step backwards, puts her hands on her hips and then leaves the group.

Soon after her suggestion the teacher leaves the group and the pupils continues the work on their own:

Time	Speech (Pupils)	Speech (T)	Gestures (S)	Gestures (T)	Body and gaze (S)	Body and gaze (T)
	#-what, okey					
	#-I see				G2 leans her head in her hand. She looks troubled.	
7:18	B-Here, give me that		B takes another ruler in his hand. G2 takes the measuring tape in her hand. She shrugs her shoulders.		G2 says something unhearable to G1 and looks at her. B looks at the rulers and then at the teacher (like he wants her attention).	
7:23	G1-Can't you go and get another instrument, this was hard		B points in the teacher's direction with one of the rulers and starts pushing the pasta together in the table with the two rulers. G1 is touching the pasta in front of her. G2 holds a measuring tape in both her hands in front of her.	T1's hands and arms are freely moving.	G1 looks at the passing teacher and then at the table. She looks troubled. G2 looks at G1 and then at the passing teacher.	T1 laughes and passes the group with her front in direction to the group. Before turning to another group she looks at G2. Now her facial expression is more serious but still smiling.
7:29	B-It is just to do like this		B has two rulers in his hand and pushes the pasta together into a string. G1 holds her hand upon a pile of pasta in front of her. G2 holds her hands closely together in front of her and keeps the measuring tape in her hands.		B looks at the pasta in front of him. G1 and G2 look at B.	

7:32	G2-But how will we know how much everything is?		G2 stretches out the measuring tape and puts it on the table.		G2 looks at B and then at the table.	
7:36	B-But check it out, you take it like this and do little		B pushes the pasta together into a string with the two rulers. G1 has her hands on the pasta in front of her. G2 has her hands on the measuring tape on the table in front of her.		G2 looks at the pasta in front of G1. B looks at the rulers that he is working with. G looks first at the pasta in front of her and then at what B is doing.	

First the pupils still do not know what to do. The teacher passes and one of the girls shouts to her that they want other instruments. The teacher laughs but does not stop. The boy starts pushing the pasta into strings with two rulers and he shows that he can measure the string with the measuring instrument. The girls are looking at what B is doing and after this all three of them do the same thing.

In the analysis for each episode I focus on the three questions, which correspond to the three functions. This is the analysis of this episode:

A. Ideational meaning: The pupils are showing how they make meaning in relation to numbers and also problem solving, when they are putting the pasta pieces into groups of tens. This could, in fact, be seen as a kind of measurement. However, none of this shown knowledge does the teacher show acknowledgement of. Her interest is focused on measurement with the use of the instruments.

B. Textual meaning: The teacher approaches the group and with a quick glance at the table and at the pupils' gestures, bodies and gazes she seems to become aware of what they are doing. The pupils do not from the beginning seem to focus on what the teacher is talking about. They answer her but they are still looking at the table and one of them continues counting. The affordance of gestures is present when the teacher shows something on the table. All pupils in the group lean forward and look at the teacher's hands.

C. Interpersonal meaning: In this episode the teacher gives explicit feedback on what the pupils "should" do next in the mode of speech to the group. She does not give any positive feedback on the signs of meaning-making that the pupils show when she approaches. Later in the interaction she recalls an earlier event and gives feedback on what happened before in the group, what signs of meaning-making she saw then. Most of the feedback is focused on what the group is supposed to do (as opposed to what the group might be learning) and that the teacher might expect the pupils to manage to go through with the task (her laugh).

SUMMARY OF THE WHOLE LESSON

Looking at the lesson as a whole the pattern follows the episode above. In the end of the lesson it is clear that the teachers' intent with the lesson is measuring volume but this is, as I see it, not obvious to the pupils in the class. The mathematical content that is present in the teachers' actions is, most of the time, the use of the measuring

instruments. The focus that the teachers show is more about *doing measurement in a certain way* than *investigating different possibilities to measure (in this case pasta)*. When the pupils show meaning-making which is not included in the teachers' plan for the lesson the teachers do not acknowledge this. It is clear that different modes have different affordances according to the people involved and to the situation, and both teachers and pupils are communicating via speech, gestures etc. The teachers acknowledge modes as gestures in most occasions, but not all the time. At the end of the lesson the pupils in the group have finally solved the task in a way that the rest of the class appreciates (they measure "strings" of pasta and come to the answer 2 meters and 44 centimetres). However, the teachers' feedback is focused on that this method took a long time and was troublesome.

DISCUSSION AND POSSIBLE EXPLANATIONS

When studying the classroom communication in these situations, using the multimodal approach, I find many incidents of formative assessment – that is communication that can be expected to, or at least have the potential to, contribute to the forming of the pupils' mathematical knowledge. Multimodal transcriptions are time-consuming, but do really reveal important aspects of the assessment interaction in mathematics.

A conclusion of the analyses is that the teachers' most important aim of the lesson is the advantages that can be found when using volume instruments to measure (in this case pasta). According to this aim all the teachers' actions are understandable. Throughout the lesson their feedback goes in this direction, so the teachers' actions are very consistent. Their aim with the lesson becomes highly apparent in the end of the lesson when the whole class is gathered. They point out that measuring pasta with a ruler is time consuming and troublesome (despite the fact that the pupils in the class find the method preferable) whereas they point out that other methods are easy to handle (despite the fact that one group using measuring cups find it time consuming and difficult). The teachers are very focused at their aim but on the other hand they stress neither the goal of interest and confidence, nor the general goal of measurement. The pupils followed in this study are really doing what they are told, showing meaning-making during the work, and after a lot of effort they succeed measuring the pasta with the ruler and measuring-tape. Nevertheless the teachers do not, as I see it, give much constructive feedback, which could provide the pupils with possibilities to build on their interest and confidence in mathematics. Constructive feedback on measuring in general would give opportunities for more learning about measurement. Maybe this, the issue about the different goals, is a main point? There are many goals in the syllabus to follow in the teaching and it can be hard for the teachers to capture several of them at the same time. Another question is in what ways the discourses the teachers are part of when it comes to school mathematics affect their teaching and what meaning-making they "capture".

An issue that arises when looking at the results from an institutional perspective (Rostwall & West, 2005) (which is quite close to "context of culture" discussed by Morgan (2006)) is about the collaborative project in which the teachers participated. I start to wonder how much collaboration the teachers have experienced during the project. Maybe the lesson in this study is a lesson which the teachers do not feel familiar with? Maybe they are trying to copy a lesson plan, which they do not grasp fully? If this is the case the teachers' actions are even more understandable. It also points at important issues concerning in-service and collaborative projects with teachers in general, namely issues of cooperative learning for researchers, teachers and pupils and also issues of respect for the teachers' professionalism and for the pupils' contributions to the lessons in mathematics.

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