Researching Classroom Assessment in Mathematics: Theoretical considerations

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The main theme in this paper is what a use of multimodal social semiotic and discursive/institutional theories can convey when researching assessment displayed through feedback in mathematics classrooms. The theories were operationalized in a project finished by the end of 2011. A secondary theme in the paper is to present the main findings of the project. These findings consist of four discourses of assessment in mathematics classrooms, in which also roles of semiotic resources (e.g. graphs, gestures, speech) are taken into account. The discourses and how these are present in institutional traces (e.g. decisions on a municipality level) are means for addressing the mathematics classroom as part of and affected by a broader institutional context.

Classroom assessment in mathematics

The basis for this paper is a recently finished research project (Björklund Boistrup, 2010). I have chosen to focus on major theoretical considerations, while simultaneously presenting the main findings. Consequently, other parts of the study, such as methods, are described briefly.

In the project, teacher-student communication in mathematics classrooms were examined with an interest in assessment displayed through feedback in day-to-day communication. The research question foregrounded in this paper is "What discourses of classroom assessment in mathematics can be construed and what affordances can be connected to students' learning and active agency (described below)?" I also connect to a question about what institutional traces can be identified in relation to the construed discourses. The study is one answer to a call since Black & Wiliam (1998, see also Hattie & Timperley, 2007) for classroom studies in depth on classroom assessment. Moreover, it is aligned with an argument that studies on assessment based on a social perspective are needed in mathematics education (Morgan, 2000). The concept of classroom assessment is in this study taken to be a concept with broad boundaries. Assessment through feedback takes place explicitly when students are given their mathematics test results. But often, assessment is implicit during teacher-student interaction (see Figure 1).

In the data gathering, two students in each of the five grade 4 classes were randomly (for ethical reasons) chosen and the analyses were focused on the

interaction between these two students and the teacher. The data material consisted of video recordings and written material.

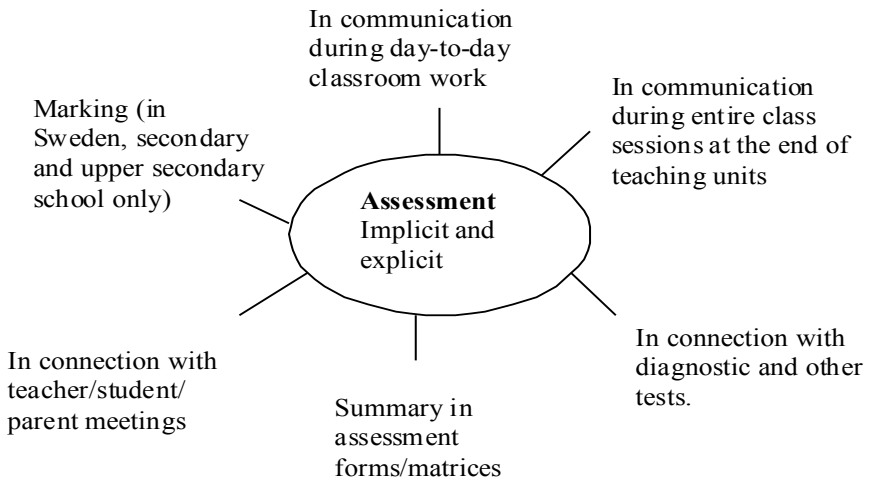

Figure 1. Assessment: A concept with broad boundaries (adapted from Björklund Boistrup & Lindberg, 2007, poster).

Social semiotics and discourses

In social semiotics, the interest is directed towards communication, with special attention given to a broad range of semiotic resources (e.g. graphs, speech, gestures) and their relation to each other and the social practice (Kress et al., 2001; Van Leeuwen, 2005). Consequently, all kinds of semiotic resources need to be taken into consideration, in assessment in mathematics and in research on assessment. Assessment of learning is from a social semiotic perspective about acting on signs of learning, as shown by semiotic resources. In adopting a social semiotic perspective, a central notion is that what a semiotic resource represents and communicates depends on the interest of the person using that semiotic resource, the existing situation and the broader institutional context. In O'Halloran (2000) there is an interest in three semiotic resources: mathematical symbolism, visual display and language, and the author addresses the impact that the multisemiotic nature of mathematics has on classroom discourse. In this paper, the range of possible semiotic resources is broader, including gestures and gazes etc. Here, learning is understood as meaning making towards an increased readiness to engage in the world with an increased use of semiotic resources in a discipline such as mathematics (Selander & Rostvall 2008).

Inspired by Halliday (2004), social semioticians usually talk about three communicative meta-functions: 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 paper the meta-functions contribute to the construed discourses. The interpersonal meta-function is about how language (used in a broad sense in this paper) enacts "our personal and

social relationships with the other people around us" (Halliday 2004, p 29). Here it concerns what kind of assessment in the form of feedback is taking place in the interaction between teacher and student. The ideational meta-function is related to human experience and representations of the world (Halliday 2004). In this paper it concerns what aspects relative to the mathematics classroom are represented and communicated in the assessments. The textual meta-function is related to the construction of a "text", and this refers to the formation of whole entities which are communicatively meaningful (Halliday 2004). Here the interest lies in what roles different semiotic resources play in assessment.

Drawing mainly on Foucault (1993, 2002), the other of the two main perspectives in this paper is an institutional/discursive perspective. Assessment in mathematics education is taking place in school with institutional aspects present, aspects which have both direct and indirect effects. Decisions may be made at different "levels" in the school system, and have a direct impact on the classroom work. There are also indirect aspects, such as classificatory systems, norms and dominant discourses (traditions) developed over time.

According to Foucault (1993; 2002) discourse is conceptualised as a broad notion that incorporates not only all statements but also the rules that affect the formation of possible statements. Consequently, the discourse is more than the entirety of what is communicated and the way it is communicated. It can be construed from what is not communicated, or what is communicated through gestures, attitudes, presentations, patterns of actions, and the rooms and furniture. For the people who are part of a discursive practice, the rules of the discourses affect what actions are possible to take. For example, there are certain things that are "allowed" to be communicated, and certain ways to communicate them. With respect to this, it should be said that discourse according to Foucault (2002) is to be conceptualised in line with a dynamic view (Björklund Boistrup & Selander, 2009). This dynamic view holds that the participants are not to be seen as imprisoned in a discourse. They can both be part of a long-term change of the discourse and "leave" it and instead take active agency in another discourse. This dynamic view involves a strong position for the individual, and agency is another concept operationalised in the analysis (see also Mellin Olsen, 1993). Agency is understood here as a capacity for people, in this study mainly students, to make choices and to impose those choices on the world. This is a matter of a person being active or passive.

Operationalising theories

The transcription was performed multimodal according to the social semiotic perspective which allowed capturing various feedback as well as aspects of the focus of the feedback. This is shown in a following section where some of the main findings are exemplified. In the study, the notion of discourse is used as an

analytical concept. One way to describe assessment practice in a mathematics classroom is through the discourses that can be construed from the classroom communication. A starting point was a dichotomy of "traditional" and "active participant" discourses (Björklund Boistrup & Selander, 2009). In the analysis, these two discourses were identified in the data, but variations on them began to appear. Several tentative discourses emerged during the analysis, and I considered the ones that appeared to be the most "solid" ones. A basis for the construal of the discourses were the findings of the three initial analyses, which are connected to the three social semiotic meta-functions: (1) What kinds of assessment acts are present (drawing on Hattie & Timperley, 2007); (2) What are the focuses of the assessment acts in the mathematics classroom (drawing on Hattie & Timperley, 2007, and Skovsmose, 2005); and (3) What roles do semiotic resources play in the assessment acts. Essential when construing the discourses were the affordances for learning and/or students' active agency in the mathematics classroom.

To summarise, the process of construing the discourses (drawing on Foucault, 2002) included these steps: (a) using the dichotomous discourses in an early attempt to interpret the material, (b) broadening the first two discourses by capturing deviations from, and opposites to them, (c) choosing the most durable ones among the proposed discourses, (d) aligning the discourses with the purpose of the study in using the social semiotic meta-functions as a basis and (e) rechecking the discourses against the material (also in discussion with others).

Four assessment discourses in mathematics classrooms

The first of the four construed discourses is called "Do it quick and do it right", and has similarities to the traditional discourse mentioned in previous section. The second, "Anything goes", is more of the opposite to a traditional discourse and here students' performances that can be regarded as mathematically incorrect are left unchallenged. The third, "Openness to mathematics", has similarities with the active participant discourse mentioned in the previous section. Finally, the fourth, "Reasoning takes time", takes it one step further with a slower pace and an emphasis on mathematics processes such as reasoning and problem-solving.

Do it quick and do it right: In this discourse, the *feed back* is communicated mostly from teacher to student. Questions posed by the teacher are not often open and there are rarely follow-up questions. The *feed forward* concerns a non-reflective doing not connected to mathematics processes, and the teacher not often challenges students' reasoning. *Feed up* (feed back and forward related to goals) is not present in this discourse. The focus is not on mathematics processes but on whether an answer is right or wrong, or the number of accomplished items (a *task focus*). The *semiotic resources* used are not based on a consideration with

regards to the learning of mathematics. Both teacher and student communicate in short utterances, and there are rarely longer silences. As a consequence, the lack of focus on mathematics processes allows low affordances for students' learning of mathematics. The main agent in this discourse is the teacher, and the affordances for students' active agency are not high.

Anything goes: There is not much articulated *feed back* in the discourse "Anything goes", apart from occasional approval. Here too, the *feed back* is mainly from teacher to student. There is a presence of also open questions. The student is rarely challenged with respect to mathematics. Infrequently there are constructive discussions about students' solutions, and answers possible to consider as mathematically wrong can be left unchallenged. Different *semiotic resources*, including artefacts, are welcomed, and semiotic resources are rarely restricted. The teacher and students use short sentences, and there is not much silence. Often in this discourse, the teacher is the most active agent. Sometimes the teacher takes a more passive role in the discourse. S/he then does not interfere with students' reasoning even though something possible to consider as mathematically wrong is demonstrated. The affordances for students' learning and active agency in this discourse are considered low.

Openness to mathematics: There are several instances of *feed back* and *feed-forward* in this discourse, both from teacher to student and vice versa. Quite often the questions posed are open. Often the teacher and student show interest in mathematics and there is also an awareness of students' alternative interpretations of tasks. Sometimes the student is challenged with respect to her/his continued learning. Often the *focus* is on *processes* like knowing facts, practicing and routine. "Wrong" answers are also starting points for a talk, but, in the end, it is always clear what can be considered mathematically correct. Different *semiotic resources* are acknowledged and at times the teacher promotes, whilst at other times restricts, the use of semiotic resources dependent upon the meaning making and learning process demonstrated by the student(s). The lengths of teacher-student interactions are quite short. In this discourse, there are considered to be affordances for students' learning of mathematics and active agency.

Reasoning takes time: In this discourse, *feed back, feed forward* and *feed up* can be present and in both directions between teacher and student. There are often instances of recognition of students' demonstrated knowing, sometimes in relation to stated criteria. The students are often challenged towards new learning. The *focus* is on *processes*, with emphasis on *processes* like inquiring/problem-solving, reasoning/arguing, defining/describing and occasionally constructing/creating. Different *semiotic resources* are acknowledged, and the use of *semiotic resources* can also be promoted or restricted when serving a certain process. Here, silence is common and the

possibility (for both teacher and student) to be silent seems to serve the mathematics focus. In this discourse, the affordances for students' learning of mathematics are considered to be high, including a wide range of mathematics processes. Similarly, the affordances for students to take active agency are high.

Two of the four discourses construed from classroom communication

In addressing the first discourse, "Do it quick and do it right", we encounter a lesson where the students are working on their own in the textbook. Cecilia (Teacher) arrives at Catrin's (Student) desk to check a completed diagnostic test, and they both look at her work.

Time	Speech	Gestures	Body and Gaze
15:29	Cecilia (T): *One.* (*silence 2 s*) *"Which angles are straight?"* *A and?*	Cecilia (T) has a red pencil in her hand, ready to write. Catrin (S) holds a pencil.	Cecilia (T) is standing behind Catrin (S) and leaning over her.
15:35	Catrin (S): *B.*		Catrin (S) looks at the angles in the textbook.
15:36	Cecilia (T): *Yes, good.*		
15:37		Cecilia (T) writes an R in Catrin's (S) notebook.	

Excerpt 1. Multimodal transcript from video material.

In Excerpt 1, a pattern is clear, which continues for two more questions; Cecilia (T) reads a question from the diagnostic test (after 15 minutes and 29 seconds of the lesson) and Catrin (S) answers the same thing she has written in her notebook (at 15:35). Cecilia (T) marks R with her red pencil. In the following this pattern changes when Cecilia (T) comments on the writing of digits for the items in Catrin's (S) notebook. "What big digits you've made!" Cecilia (T) writes the digits in ordinary size in the margin of the page and tells Catrin (S) to do the same in the future.

The reasons for considering this to be an example of the discourse "Do it quick and do it right" are: (a) The only feed back and/or feed forward is in the direction from teacher to student; (b) There is a focus on the correct answers of the tasks (which is communicated at the very beginning of the sequence by the red pencil in Cecilia's (T) hand), and there are no follow-up questions. Later on, the focus is not on mathematics, but on the correct way to write and draw in the notebook (a task focus); (c) No considerations are made concerning semiotic resources, and there are few silences and short utterances; (d) The lack of focus on mathematics processes provides low affordances for the student's learning of mathematics and there are few affordances for the student to take active agency.

In the following sequence, from which "Reasoning takes time" was construed, Eddie (S), Enzo (S) and Ed (S), are working on an assignment. They are presented with five different solutions to the same task (376 – 149 =), shown

in Excerpt 2. The students are told that the objectives for this assignment are cooperation and subtraction. They should find the suitable solution as well as determine what can be regarded as mathematically wrong with the other four.

1. 370-150=220
   220+6-1=225

2. 380-150=230
   230-4+1=227

3. 300-100=200
   200-30-3=167

4. 300-100=200
   70-40=30
   6-9=3
   200+30+3=233

5. 376-100=276-40=236-9=227

Excerpt 2. Transcript from written material. Assignment presented to students.

After Erika's (T) instructions at the beginning of the lesson, the groups start working. Erika (T) stands for several minutes in front of the class observing the students' work. Eddie (S), Enzo (S) and Ed (S) discuss the solutions. Enzo (S) raises his hand and calls for attention. Erika (T) arrives and Enzo (S) poses a question about there being two solutions with the same, and mathematically correct, answer: solutions 2 and 5. Erika (S) leans over their desks, looking at their work and posing questions to the three students about the purpose of the task (that only one solution is correct). She also asks how they have reasoned so far. Part of the communication is shown in Excerpt 3.

Time	Speech	Gestures	Body and Gaze
15:05	Erika (T): *What is your thinking then?*		Erika (T) looks at the worksheets.
15:07	Enzo (S): *Look.*		Ed (S) looks at 376 – 149.
15:08	Ed (S): *Well, that's two hundred twenty seven.* [Enzo (S): *And that is*] *That one can't be right.*	Ed (S) points at 376 – 149. Enzo (S) points at solution 4. Ed (S) points at solution 2.	 Enzo (S) looks at solution 4. Ed (S) looks at solution 2. Enzo (S) looks at solution 2.
15:11	(silence 2 s) Ed (S): You take plus four when it should be minus four.		
15:16	(silence 3 s) Enzo (S): *No, minus four, that's six plus one, that's also the same.* (*silence 3 s*)	 Enzo (S) points at solution 2. Enzo (S) stops pointing.	Students look at worksheet. Enzo (S) looks at Ed (S). Enzo (S) looks down.

Excerpt 3. Multimodal transcript from video material. Speech in brackets, [ ], signals simultaneous speech.

As shown in Excerpt 3, there are substantial pauses in the communication. Sometimes these silences are followed by reasoning from one of the students. After a while, the students' reasoning becomes more intense with a sustained

focus on the mathematics involved in the task. Here, the students communicate their ideas for several seconds each. In one instance, Erika (T) points at solution 5 and asks whether they have done a calculation in that way before in class. The students answer no, and then there is a short discussion about solution 2. Before leaving, Erika (T) tells them that they get a few minutes more to think and also advises them to write down what is wrong with the ones that they know are definitely wrong.

The reasons why this is considered to be an example of the discourse "Reasoning takes time" are: (a) There are several instances of feed back and feed forward. Erika (T) communicates feed back and feed forward to the students about their work. The students ask for feed forward on the task and their demonstrated knowing is used as feed forward by Erika (T) for her future acts; (b) The focus of the feed back and feed forward is mainly on mathematics processes. The processes that are present, even after Erika (T) has left, are mainly reasoning/arguing and inquiring/problem-solving. Before leaving, Erika (T) also initiates the process of defining/describing since she tells them to write down their reasoning so far; (c) The feed back and feed forward from Erika (T) are realised several times by questions to the students. There are many instances of silence followed by utterances from the students as well as from Erika (T). There is also a silence when Erika (T), just prior to this sequence, stands in front of the class observing the students' work. She introduces semiotic resources and then promotes the process of describing when she tells them to write down their work so far; (d) They communicate a great deal about mathematics by way of speech, gestures, symbols on the paper etc. also in longer utterances. There are affordances for students' learning of several mathematics processes here. Moreover, there are considered to be affordances for students' active agency here, and the students take active agency in the sequence.

What the theories made possible

The engagement in social semiotic theory conveyed a possibility to view assessment as one aspect of classroom communication. In the analysis, the multimodal transcriptions revealed assessment communicated through semiotic resources such as gaze and gestures. Additionally, it gave a clear picture of the focus of the assessments through pictures, gestures, writings etc. The semiotic resources were in the analysis shown to play essential roles for the assessments. One example is whether there were any considerations made with regards to which semiotic resources the students could use when displaying mathematics knowing. It also provided a structure, through the meta-functions, around which I could organise the first three analyses as well as means for the construal of the discourses.

When it comes to the institutional/discursive perspective, I want to stress that I do not claim that discourses are anything more than an analytical concept. Moreover, in each classroom it was possible to construe at least two of the four discourses and often there could be changes during one lesson. One advantage of this theory is that it provides means to discuss and understand the assessment in mathematics classrooms as well as viewing the classroom as part of a broader context. The discourses in this study were construed in the institution of school, where acts in one assessment discourse are taken for granted. There are acts that are unlikely to appear in other assessment discourses in the mathematics classroom. One example where "Do it quick and do it right" is present is when a teacher communicating with a student about the student's performance on a diagnostic test focuses the feedback mainly on how to keep the student's notebook in order. She states that mathematics is a "clear-cut subject". In an alternative assessment discourse, for example "Openness to mathematics", there could, of course, be feedback on the preference for mathematics notes being kept in reasonable order. But in this discourse, this would be related to the importance of mathematics processes not getting lost in the student's notes. Here, the acts could be described as following the "rule" "mathematics processes are the primary focus in the mathematics classroom". Institutional traces like discourses are more indirect than decisions made by authorities, decisions that teachers have to follow; nevertheless, they can be perceived to be as strong.

Direct institutional traces, such as a decision on municipality level regarding the use of a certain assessment material, are considered to "carry" (introduce and/or maintain) all four discourses in the study. This occurs when a situation also includes a direct institutional trace and may have had an impact on which discourse that could be construed from the situation. This illustrates that why things are the way they are with respect to assessment in the mathematics classroom is far from simply being a question of the individual teacher. For politicians, decisions are sometimes made on a national or municipal level that counteract what is stated in steering documents.

Hence, what assessment discourses can be construed in mathematics classrooms is a matter of a complex interplay between steering documents, decisions made on different levels within and outside the institution of school, and dominant traditional discourses, as well as alternative discourses and agents in discursive practices. A positive change in affordances for students' learning and active agency of mathematics with respect to classroom assessment is a question of looking at every part of this interplay as a whole (Pettersson, 2010). One issue is that decisions about school must be coherent with regards to these affordances and thus not counteract one other. The discourses presented here can then be a basis for discussions and decisions concerning assessment in mathematics classrooms on different levels in the institution of school.

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