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Justifications for mathematics teaching: A case study of a mathematics teacher in collegial collaboration

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The broad interest of this paper lies in how a mathematics teacher, Mary, justifies her professional decision making. The reported study draws on aspects of a PhD project and analyses Mary's communications within a collaborative teacher meeting focused on the teaching of mathematics to grade five students. The analysis, drawing on social semiotics, highlighted the significance of artefacts, such as multiplication tests, in Mary's articulated decision making. We also give account for what is addressed in a teacher's justifications and how the teacher relates to her students in the justifications. Finally, we discuss the wider social and political context in which the teacher is working.

Keywords: Mathematics teacher, mathematics teaching, teacher collaboration, case study, social semiotics.

INTRODUCTION

This paper is about a primary school teacher specialised in mathematics and science, Mary (pseudonym). She has about fifteen years of teaching experience. Together with Mary there are three teachers teaching about 100 fifth graders and they meet alternate weeks to discuss the mathematics they will be teaching. This study focuses on one of these meetings when the group discussed the assessment of multiplication tables and the use of textbooks to differentiate teaching. We followed Mary's communication through the meeting with an interest in how she justifies her professional decision making.

It is a challenge to discuss and understand why a mathematics teacher teaches the way she does. An easy response could be that the curriculum says so; another answer might be that the text book says so. From our perspective it is, in such a discussion, essential to un-

derstand that teachers' actions are undertaken within a particular social and political context. One example of this is how for the last twenty years, Sweden has had a decentralised curriculum that has forced autonomy on teachers. This forced autonomy, which has moved teachers to the centre stage of curriculum enactment (Skott, 2004), raises the demands on mathematics teachers to make informed decisions in the very complex set of actions that constitutes mathematics teaching. As a basis for teacher decisions there are different aspects of justifications possible to construe. The aim in this paper is, from a perspective close to a teacher's, to investigate her justifications when she discusses mathematics teaching with her colleagues. We also discuss the wider social and political context in which the teacher works, while focusing on artefacts as a part of the school system. We pose the following research questions:

- 1) What role do artefacts play in Mary's justifications in the teacher meeting?
- 2) What circumstances, contents and ideas are addressed in Mary's justifications?
- 3) What relational aspects concerning herself as a teacher and her students are a part of Mary's justifications?

LITERATURE REVIEW

When studying teachers in their social settings, one possibility is to examine how they collaborate with colleagues. Even though teachers are autonomous they need to work in close relationship with colleagues, parents and students (Hargreaves, 1994). Findings from research about teacher collaboration indicate that collaboration within a culture where

teachers engage in mathematics teaching together, have a positive impact on both teaching practices and student achievements (e.g., Honingh & Hooge, 2014). Research situated in teacher collaboration is often used to study teacher development programs, e.g. professional learning communities (Riveros, 2012), communities of inquiry (Goodchild, 2014) or learning studies, which are common in Sweden today (e.g., Kullberg, Runesson, & Mårtensson, 2014).

Teacher collaboration research is rarely situated in a naturalistic setting, with a collaboration that would have taken place whether the researcher was there or not. A review of CERME proceedings 6, 7 and 8 reveal only a few papers on teacher collaboration (e.g., Spencer & Edwards, 2011) and none situated in an everyday situation. If research is situated in a development program it could be difficult to distinguish if the positive effects come from the collaboration or if it is from being in a development program. Here we can see a need for more studies on teacher's everyday life, also teacher collaboration.

Studies concerning mathematics teachers and their practices are diverse. In literature relevant for this study we can see that different countries have different school-cultures. Cross-nationally, students receive different numbers of mathematics lessons of different length, but within countries there is considerable consistency in how mathematics teaching is executed (Andrews & Sayers, 2005). This influence of tradition and school culture on mathematics teaching is, for example, described in the way teachers engage with and use curriculum materials (e.g., Remillard, 2005). As a part of a school tradition, mathematics curricular materials such as the mathematics text-book are said to have a prominent role and bear traditional forms of discourse (e.g., Johansson, 2006; Herbel-Eisenmann, 2007). Teachers deal with a complexity including the impact of culture, tradition, curricular materials and the competing objects and motives created by teachers and students (e.g., Skott, 2001).

METHODOLOGY 1: ANALYTICAL PROCESS

We have divided the methodology into two parts. Here we describe the interplay between preliminary data analysis and theoretical considerations which led to the analytical framework that we finally exploited. In another part, below, we describe more about the research design and data collections.

In order to acquaint ourselves with the data (transcripts from teacher meetings), we undertook several constant comparison readings, inspired by Glaser & Strauss (1967), with the purpose of identifying recurrent themes focused on a teacher's professional justifications. Our interest was directed only towards those justifications that were possible to observe in Mary's utterances and not those that Mary may have kept to herself. In the initial readings three major themes emerged. One related to artefacts as part of the school system, for example multiplication tables and the role they played in the teachers' discussion. Another was "what" Mary focused on in her justifications and a third concerned interpersonal aspects such as how Mary related to her students in her justifications.

In other words, during our initial analyses we identified themes with a conceptual similarity to those of social semiotics (Halliday, 2004; Van Leeuwen, 2005, Morgan, 2006). Consequently, refocusing our analyses around functions from this theory, provided a basis for new rounds of more focused readings.

ANALYTICAL CONCEPTS – SOCIAL SEMIOTICS

There are three social semiotic meta-functions that suited our preliminary analysis: textual, ideational and interpersonal. In this paper we adopt the meta-functions mainly according to a multimodal approach (Van Leeuwen, 2005; see also Björklund Boistrup & Selander, 2009). The meta-functions are not independent, they constitute each other.

The *textual* meta-function is, in this paper, understood according to the roles different communicative resources (such as artefacts, speech, voice, gestures and the like) play in communication, (Van Leeuwen, 2005). Communicative resources then constitute texts in a broader sense than only taking language into account. In this paper our interest is focused on what roles artefacts, for example textbooks, play in Mary's communication.

The *ideational* meta-function is used to reflect the explicit content of the communication under scrutiny (Herbel-Eisenmann & Otten, 2011). In this paper the ideational meta-function is used to discern what Mary focuses on and addresses in her observable justifications.

The *interpersonal* meta-function can be used to describe interactions, roles and relations between people “who are the participants in the interaction /.../ what relationships do they have to each other and to subject matter” (Morgan, 2006, p. 229). In this paper this meta-function is mainly adopted to construe how Mary relates to the students in her justifications.

METHODOLOGY 2: RESEARCH DESIGN AND DATA COLLECTION

Trying to understand a case, in this case when one teacher is studied, within the social setting and investigate it with depth is how case studies are used (Hammersley & Gomm, 2009). Consequently, we do not seek to offer material for generalisation but to provide a description of a part of one teacher’s reality, and the result will widen our experience of mathematics teachers and these kinds of situations which could be seen as an alternative to generalisability in case study research (Donmoyer, 2009).

In this paper the collaboration between Mary and her colleagues served as the social setting where communications on mathematics teaching could be observed. We followed teacher meetings when Mary and her colleagues discussed different problems and possibilities concerning their mathematics teaching. Here we concentrate on one of the teacher meetings, although data on eight other meetings served as a background, and helped our understanding of this particular meeting. In order to capture mathematics teachers’ collaborative discussions, audio recordings were made and transcribed directly in the software Videograph [1]. The same software was used to assign codes in terms of the research interest.

ANALYSIS AND FINDINGS

We present two excerpts, followed by our summary analysis, from the teacher meeting between Mary and her colleagues: Tomas, educated in advanced mathematics, but not in education; Peter, an experienced primary school mathematics teacher like Mary; and Sara, a primary school mathematics teacher a little bit less experienced than Mary and a new teacher at the school. The described excerpts serve as to illustrate the various features identified from the teacher meeting. The analysis draws on the three meta-functions which also are reflected in the research questions.

Episode 1: Discussion of a multiplication test

In the beginning of the teacher meeting a new teacher, Sara, was invited to describe what she had done during the previous week. Tomas, the official leader of the group, stated that one of Sara’s teaching actions has been “really good” and referred the group to a times tables test comprising items such as 6×7 , (the “really good” refers to the teacher having the test and not to the result of the test). In the following we present an episode from the meeting. To make the analysis as transparent as possible, some comments have been added to the excerpt.

- 1 Sara: Yes, and then I did the multiplication test in the afternoon
 /.../ [The teacher group talk about the result of the test which was not satisfactory]
- 2 Peter: How many did you do? Five?
 3 Sara: Five minutes
 4 Peter: Hundred exercises?
 5 Tomas: How many exercises?
 6 Sara: Hundred and twenty exercises
 /.../ [They talk about the test and other topics for about ten minutes]
- 7 Tomas: Er, but then we have one or two in one class that thinks maths is like the plague and really hard, and that always feels like, and that has its grounds in this multiplication and then it was the worst anxiety attack and tears fell and it, it is really tough.
- 8 Mary: Arr! [Said with a voice construed as compassionate]
 /.../ [About five minutes of discussion on other topics]
- 9 Mary: I am sitting here thinking about your test, 120 exercises in 5 minute. Is that reasonable is it a lot or little or is it...
- 10 Sofia: That is reasonable! I had students that did it in three minutes
- 11 Mary: Ah, well then
 12 Sofia: Two and a half minutes, if you know them it is there...
- 13 Mary: Then it is...
 14 Peter: Yes
 15 Sofia: When you see the problem you know that it is, you don’t have to.
- 16 Mary: You don’t have to figure something out no that is good...

- 17 Tomas: I can agree, if it was a long ago since last time, you could get seven, eight minutes the first time.
- 18 Mary: Yes
- 19 Tomas: But the thing you test is if they have automated it if they know...
- 20 Peter: Hmm
- 21 Tomas: Not that they will sit there and think five times five let's see that is five that is ten that is fifteen that is twenty, twenty five...
- 22 Mary: No, that's not, you don't have time for that...
- 23 Tomas: They should know that five times five is twenty five.
- 24 Mary: Hmm

Analysis of Episode 1

We view the test as an artefact and thus part of the multimodal “text” (Van Leeuwen, 2005). In this *textual* analysis we adopted social semiotics as “the way people use semiotic ‘resources’ both to produce communicative artefacts and events and to interpret them [...] in the context of specific social situations and practices” (ibid, p. xi). Our analysis revealed that, for Mary, the test played the role of reflecting the students’ knowledge of automated multiplication skills. As the teachers discussed the test they talked about how the test was organised (line 2–6 and 9–14), and what the students need to know (line 12, 15–16, 19–24). We can also see the test having the role of a tradition keeper. Peter, who asked the question about how Sara did the test (line 2), almost said the answer together with Sara. This idea of having about 100 exercises in five minutes’ was only questioned by Mary, for example, in line 9. No one offered an alternative or questioned the organisation of it. This way of doing this test seemed to be taken for granted. Drawing on Björklund Boistrup (2015), we argue that artefacts like this test, and how it is executed, are part of the assessment tradition within Swedish mathematics education. Looking at old Swedish text books, similar tests are found in teacher guides, so it can be inferred that this is part of a long term Swedish mathematics teaching tradition. When Mary tried to challenge the role of this test, she had not only her colleagues to argue against, she had a whole testing tradition to speak against.

We adopted the *ideational* meta-function (Herbel-Eisenmann & Otten, 2011) to analyse “what is being talked about or the specific content of the interaction”. In this case, the content matter of Mary’s justifications

was knowledge concerning the automated recall of the multiplication tables. We construed this from the episode when Mary (line 16) said that it was good when the students do not have to calculate to know how much a simple multiplication is. In line 22 she agreed with Tomas that the test situation did not give time for calculation, and this was interpreted as Mary viewing it to be important when testing automated knowledge. Mary also agreed with Tomas in line 24 that the students should know five times five. Our analysis identified that Mary justified the test with the argument that the automated knowledge of the times tables is important mathematical knowledge. This was also present when the teachers talked, in another episode not discussed here, where Tomas said “they understand how you should calculate the more difficult exercises but since they don’t know the times table it turns out wrong any way”. On this occasion, Mary agreed with an “mm”. This notion of ‘important knowledge’ was one of justification for Mary’s support of the test.

We also identified an *ideational* aspect from Mary’s justifications in an episode before this one, where Mary displayed resistance to the test. She then justified her questions and proposals drawing on the matter of how to organise classroom work in mathematics teaching. She stated that testing multiplication tables could take too much time from her lessons, saying “I do that in third and fourth grade but after that I don’t want to use time from my lessons on this”. Here we construed a hesitation in Mary’s communication about the importance of doing the test.

Looking at *interpersonal* aspects in Mary’s justifications, we were inspired by Morgan’s (2006) description of the interpersonal meta-function as bringing forth relational aspects as well as “meanings, including the possibilities for emotional experiences” (p. 224). We then focused on how Mary’s justifications in this episode concerned her relations with and emotions towards her students. Beginning at line 9, we identified a conclusion in Mary’s question; that this test might not be for all students. A care for students is construed in Mary’s justifications for resisting the test. Throughout the meeting Mary expressed a care for “low performing” students in relation to the test, for example her response to Tomas statement in line 7. Our understanding from this analysis is that the justification for Mary’s resistance to the test came from this care for the students.

Episode 2: Discussion of mathematics textbooks

The next episode is when the teachers discuss text books. In this case the discussion concerns what text books to have available for the students.

- 1 Mary: Yes, I will probably have Tom, he is on chapter four now, he will finish it soon...
- 2 Tomas: Yes, then we have the book for grade six
- 3 Mary: But then we have it so I don't have to order...
- /.../ [A few minutes discussion on what books to order and not]
- 4 Tomas: /.../ Peter and I agreed on, what we see as a wise thing. Those who work with more advanced mathematics so to say than grade five, they need two books. One for grade five and one for grade six /.../ they will do a test on this section to show, I can do this. If you showed that you can you can work in the grade six book but if you can't, then you need the teaching for grade five /.../ if it is too easy, you can show me that you can
- 5 Mary: That's right
- 6 Tomas: /.../ if they show us what they can do we should not hold them back.
- 7 Mary: No

Analysis of episode 2

In our analysis we construed the role of the text book as a differentiating artefact. Mary agreed with Thomas, when he argued that if the students have a text book relevant for the "own level" they will have mathematics teaching suitable for their knowledge (line 1–2 and 4–7). This idea of using the text book as the solution for differentiated teaching says something about the position the text book holds.

Again we adopted the ideational meta-function to help us identify the idea that "high achieving" children need differentiated mathematics teaching. We construed that the teachers wanted to achieve a teaching suitable for these students through offering them more advanced text books. The teachers all agreed on the textbook as differentiator, as we can see when Tomas and Mary discussed this in lines 1–7. Tomas and Peter also had a special solution in line 4, concerning how to organise who get access to the more advanced text book and who does not. Mary justified her support for the idea when she expressed the need

for one of these text books in her own classroom (line 1–3) and when she agreed with Tomas' idea in line 5. This is also construed from line 7 when Mary agreed that the students should not be "held back".

Looking at the interpersonal aspects of Mary's justifications, we can see how Mary agreed with Tomas in line 5, when he stated that the students could be trusted to take the responsibility to show what they can do before they got a text book different from the rest of the class. Here we construed that Mary related to her students with trust.

Another interpersonal aspect is construed when Mary, in line 1, made sure that there was a book for one of her students who would need it very soon. Here we identified that Mary related to her student with care, but, when compared to the case of multiplication tests, this time the care was for the high achieving students and the purpose was to challenge, not to be careful with.

CONCLUSIONS

In these two episodes, two artefacts were identified as indicators of Mary's professional justifications: the multiplication test and the text book. In the analysis, we construed the multiplication test as playing two roles, a reflector of students' skills as well as a tradition keeper, while the text book played the role of a differentiator.

Ideational aspects were identified in Mary's justifications. When she argued for and against the multiplication test, we identified in our analysis how she argued that automated recall skills of the multiplication table is important mathematical knowledge. We also identified how she wanted to allocate time for mathematics teaching in the sense of a communicative practice and that this test was taking too much of teaching time. Discussing the mathematics text book Mary justified the need for different books with the experience that her students would need a certain book and with the idea that "high achieving" children need a differentiated mathematics teaching.

We also read in our analysis how Mary related to her students in her arguments. In both these discussions Mary related to different students with care when she expressed how the students were in some kind of need. In the first episode she addressed "low achieving" stu-

dents and the fear she had that they would suffer from failing at the test. In the second episode she addressed the “high achieving” students, whom she wanted to provide with the “right” kind of teaching. Mary also related to her students with trust when she agreed that they could be trusted to show that they could do the exercises in the ordinary text book before leaving it for a more advanced one.

To sum up, we have seen a variety of roles, ideas, experiences and relations in Mary’s justifications. The result from this small study makes it clear to us that a mathematics teacher has a very complex broader context to take into account. The roles of the artefacts, such as tradition keepers and time savers, say something of the strong position they have. Discussing them, Mary also dealt with content-related issues and her students, in terms both of what teaching they needed and what they needed emotionally. All this was visible when Mary justified her views on mathematics teaching, negotiating with her colleagues.

DISCUSSION

The three meta-functions that underpinned the analytical process facilitated a diverse description and understanding of the data. They provided ideas to view the collaborative communication in different ways with and different aspects emerged.

In the case of the multiplication test as artefact, we described Mary’s support of the test mainly in relation to an ideational aspect, the important knowledge, while her resistance appeared mainly in a relational aspect, the care for “low performing” students. This contradiction came close to what Skott (2001) describes as competing objects and motives. Something interesting here is that the importance of this knowledge wins over the care for the students, since Mary both questioned the test and seemed convinced that since they were testing automated recall it was okay. In the case of the text book as a differentiator there was support both from ideational and relational aspects which made the teacher group unanimous.

Looking at both the text book and the multiplication test with an interest in the socio-political context in which a mathematics classroom is immersed, we can see tradition (Remillard, 2005; Björklund Boistrup, 2015; Herbel-Eisenmann, 2007) shine through. The test has a role as a tradition keeper since it is a part of

the school tradition. The discussion of the text book also offers an interesting perspective, being focused on differentiated teaching. It still shows the strong position the text book holds when the teacher group unanimous justifies this idea. There is no doubt that the relation between Mary and curricular materials (text books) is very complex, and it would be interesting to see deeper analysis of the role of curricular materials in relation to tradition connected to teachers’ justifications.

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ENDNOTE

1. <http://www.dervideograph.de/enhtmlStart.html>