Zooming in mathematical conversations in the light of the formative assessment

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This paper presents the results of a qualitative study focusing on characterisation of enactment of formative assessment during mathematical conversations by Norwegian primary school teachers. Two second-grade teachers working in a primary school in a large city in Norway were observed during mathematical conversations with their pupils in station teaching regarding various strategies for addition. We suggest a model that characterises the formative assessment enacted during a mathematical conversation from a teacher's perspective.

Keywords: Formative assessment, mathematical conversations, learning of mathematics.

Introduction

Assessment is vital to the education process and it has been on the political education agenda in many countries for several years, also in Norway. In 2010 the Norwegian Directory of Education and Training started a national programme The Assessment for Learning (AfL). The involved schools worked over a period of 16 months towards an overall goal, which was "to improve formative assessment practices in the classroom by developing distinct criteria to clarify how to reach curriculum goals" (Hopfenbeck et al., 2013, p. 28). This AfL initiative was a continuation of a previous programme (Improved Assessment Practice) and as Smith (2016) stated that "despite multiple initiatives, problems with implementation /of AfL/ have remained, and the changes in classroom practice have not gone as expected" (p. 182). Several Scandinavian researchers studied how teachers develop individual AfL literacy usually within an intervention (e.g., Engelsen & Smith, 2014; Andersson & Palm, 2017). However, little is known how Norwegian teachers from schools involved in AfL programme, are practicing formative assessment nowadays.

Assessment plays an important role also in the new Norwegian curriculum (LK20), which was launched in August 2020. The competence goals in mathematics are built around six core elements and assessment is described in a special paragraph for each grade (Utdanningsdirektoratet, 2019). As stressed in LK20, assessment should help promote learning and to develop competence in mathematics. Teacher should ensure good conditions for students' participation; provide guidance and adapt teaching so that students can use the guidance to enhance their learning. The role of both the teacher and the student in the assessment process is undoubtedly essential and although student's peers are not mentioned, we see signs of formative assessment (FA) here (Cowie & Bell, 1999), despite using the word "undervegsvurdering", which literally translates as "assessment along the way". In LK20 (Utdanningsdirektoratet, 2019) a particular emphasis is also given to oral skills when students should create meaning through conversation in and about mathematics. One way how to engage students into communication in mathematics is to lead mathematical conversations (MCs), which are "not only very good methods for teachers to elicit evidence of students'

understanding and misunderstandings in order to inform the next steps in learning and teaching, they are in themselves powerful learning activities" (Swaffield, 2011, p. 443). The main purpose of a MC is to support and promote students' learning through a discussion in which students can clarify their own thinking and learn from others (Chapin et al., 2009).

In this context, and also in line with Bennet's (2011) criticism of FA related to its lack of conceptual understanding and exemplification in specific subject areas, we consider pertinent to shed a light on MCs in terms of FA. Thus, we seek to answer the following research question: *How can the enactment of formative assessment during a mathematical conversation be characterized for Norwegian primary school teachers who participated in the Assessment for Learning programme?* The study presented here was part of the main study, in which we, in addition, also tried to understand how the teachers who participated in the AfL programme, perceive FA in mathematics.

Theoretical framework

In the research field of mathematics education, several theoretical frameworks and models are designed to explain FA (e.g., Cowie & Bell, 1999; Wiliam & Thompson, 2007). Although the term *formative assessment* does not represent a well-defined set of artefacts or practices (Bennet, 2011), the following conceptualization by Cowie and Bell (1999) captures the meaning of many definitions found in the literature: FA is "the process used by teachers and students to recognise and respond to student learning in order to enhance that learning, during the learning" (p.101).

Wiliam and Thompson (2007) operationalized FA in a form where the three key processes of teaching and learning and the three agents in the classroom (teacher, peer and learner), are interconnected within the five key strategies. Cowie and Bell (1999) introduced a model (Figure 1) to describe and explain the nature of the formative assessment process in science education.

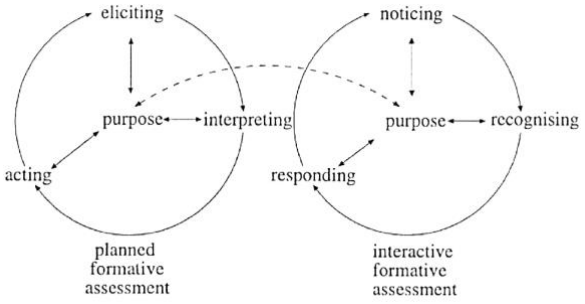


Figure 1: Model of formative assessment (Cowie & Bell, 1999, p. 113)

The model was developed from a consideration of the data collected through a research project investigating FA in science classrooms in New Zealand. It consists of two kinds of FA: *planned* and *interactive* (PFA/IFA). PFA involves *eliciting* assessment information using specific planned assessment activities, *interpreting* and *acting* on the information. The purpose for doing the assessment strongly influences the other three aspects of PFA process. IFA takes place in teacher-student(s) interactions that arise from the learning activity and are thus not planned. IFA, besides the purpose, involves also three aspects, *noticing* in the context of the learning activities,

recognizing significance of what was noticed for the development of the student's understandings and immediate *responding*. It is usually used with individual students or small groups. Teachers switch between PFA and IFA as the purpose changes. The purpose of the PFA is to obtain information from the whole class about progress in learning as specified in the curriculum to inform the teaching. The purpose of the IFA is to mediate in the learning of individual students with respect to science, personal and social learning.

Although the second key strategy of Wiliam and Thompson (2007) mentions effective classroom discussions, the model of Cowie and Bell (1999) enables us to zoom into single episodes of MCs and study, how teachers support students' learning during the learning.

Methods

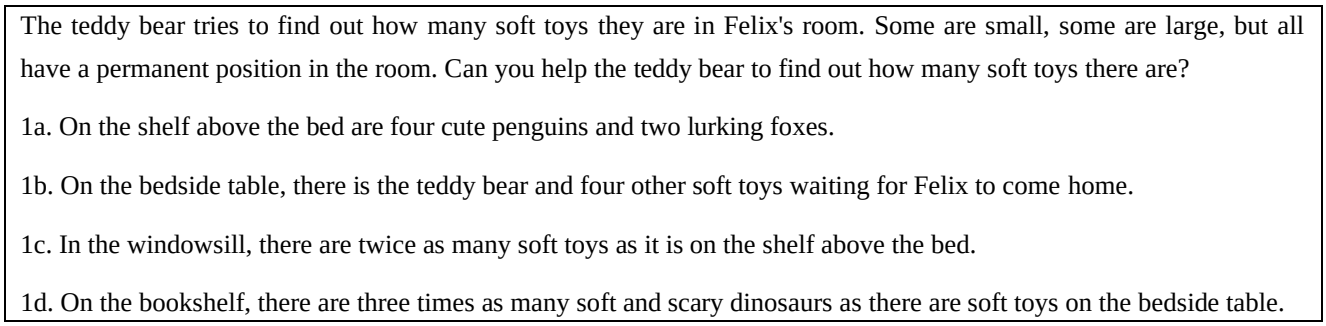
Research Context, Data Collection and Data Analysis

The data that constitutes the empirical base for this study is an observation of two second-grade teachers and their pupils during one mathematics lessons in late autumn 2018, as well as interviews with these teachers before and after the observed lesson. The interviews constitute the main source of data for other part of the earlier mentioned main study. For this study they play a supportive role, for example, regarding clarification of the learning goals of observed lessons, and additional information about typical way of performing FA, which helps us to answer our research question.

The chosen primary school in a large city in Norway was selected based on its participation in the AfL programme, as well as on its accessibility to the first author. Following criteria were used to select two teachers to participate in this study: (i) has worked as a teacher in the school for the last 8 years (participation in AfL); (ii) educated as a mathematics teacher (professional skills), (iii) teaches mathematics at the present time. Together with the headmaster of the school and the selection criteria, it was decided which teachers were asked to participate in the study. The names of pupils and teachers are altered; the teachers are called Jorunn and Hilde. In collaboration with Jorunn and Hilde and due to the purpose of the study, it was decided that station teaching was appropriate to observe. Station teaching is teaching divided into several learning activities. The teacher began the lesson by explaining the five learning activities and where in the classroom the assignments were located. Then the pupils were divided into five groups of 3-4 pupils, and the teacher decided which group to start with the different activities. The pupils worked on the same learning activity for 20 minutes. Switching from one activity to another was performed and controlled by the teacher. The content of the different learning stations was independent of each other but selected based on the teacher's thoughts on the balance between work and play. The observed station is called teacher-controlled station as the teacher participates in the pupils' learning work at that station, and none of the remaining four stations.

The learning activity the teachers chose for this station included a clue task (Figure 2), and it was for the first time Jorunn and Hilde used this type of task in a MC that focuses on addition strategies. The task consists of a text assignment and four clues. The teacher's guide to the clue task (Brataas, 2018) specifies that the teacher's role is to introduce the task, guide pupils, and lead a summary with the intention of having pupils present their solution suggestions. In other words, the learning

activity is structured in a way that allows the teacher to gather information about the pupils' learning.


The teddy bear tries to find out how many soft toys they are in Felix's room. Some are small, some are large, but all have a permanent position in the room. Can you help the teddy bear to find out how many soft toys there are?

1a. On the shelf above the bed are four cute penguins and two lurking foxes.

1b. On the bedside table, there is the teddy bear and four other soft toys waiting for Felix to come home.

1c. In the windowsill, there are twice as many soft toys as it is on the shelf above the bed.

1d. On the bookshelf, there are three times as many soft and scary dinosaurs as there are soft toys on the bedside table.

Figure 2: Clue task (Brataas, 2018, p. 2)

Both teachers used the same task in the teacher-controlled station, and both had the same structure during the lessons. The data in this study, therefore, consists of ten transcripts of MCs between the teachers and different pupils groups at the teacher-controlled station, five with Hilde (H1-H5) and five with Jorunn (J1-J5).

The analysis of the data was driven by deductive thematic analysis (Braun & Clarke, 2006) by using the four aspects (purpose; elicit/notice; interpret/recognize; act/respond) of FA from the Cowie and Bell model (1999) as codes. In the analysis we have chosen to disregard connection with PFA or IFA because our aim is not to focus on the type of FA, but its characterization during a MC.

Analysis

In this paper we present three episodes, as examples of enactment of FA during a MC. The first episode J1 is a conversation between Jorunn and a first group consisting of three pupils. Jorunn presented goals for the activity and equipment that was available on the table and gave a general description of the learning activity.

9	Jorunn:	And I have sort of a goal here, about what we are going to look at, it is about – can you three cooperate, we will look at this. Also, we will look whether you manage to double [the pupils answer yes along the way, nod and pay attention]
10	R:	What was double again?
11	Jorunn:	Yes, what was double?
12	pupils:	It's the same as plus.
13	Jorunn:	Yes, but can you give an example?
14	R:	Oh! Is it taking the same thing again?
15	Jorunn:	To take the same again, you knew it yourself! Very good. Also, there is to check if you guys had a little fun when we are done [the goal]. That's what I want us to do. Are we ready?

At the beginning of the activity, one of the pupils asked for an explanation of the term doubling (line 10). This episode may be an example of how Jorunn *noticed* and *recognized* the pupil's input as a valuable contribution to the development of pupils' understanding of the concept of doubling.

Her *response* was to give the pupil room to think, she repeated the question and also encouraged peers to help by asking for examples.

Four pupils participated in episode J3. As the pupils began working on the clue 1c, Jorunn elicited information about their learning. Large proportions of the conversation contain exchanges of meaning related to the concept of doubling.

150	Jorunn:	Yes, how many were there on the shelf above the bed then?
151	Z:	six, [counts further] seven, eight, nine, ten, eleven, twelve
152	Jorunn:	Yes, is anyone using a different strategy?
		[short break, accepting that pupil Z is counting further and actually calculating the number of toys in the windowsill]
153	Jorunn:	Do you think it was difficult and why did you write six plus five?
154	C:	I should actually have written six there [point to five on the sheet, the pupil C wrote 6 + 5]
155	Jorunn:	Okay, you can erase it. [pupil C erases it]
		[short break]
156	Jorunn:	But what strategy do you use to calculate six plus six then?
157	X:	six plus six
158	C:	ehm, I have a good one. Because .... eee sixes can be split into three
159	Z:	six
160	Jorunn:	mmm it can
161	C:	It can also be split into five, it can be split into five and five and two.
162	Jorunn:	Five and five and two yes, it works. Mmm very good.
163	Z:	six and six is
164	X:	if we have one, two, three, four,
165	Jorunn:	Was anyone using the doubling strategy then?
166	X:	five, five, six

In the episode J3, we see that Jorunn has deliberately tried to *elicit* information about the pupils' learning, but she received little response from them. It is possible to interpret it as an example of Jorunn adhering to the plan to elicit information about the pupils' doubling strategies (as expressed in the interview before the lesson), i.e. the planned formative assessment. But at the same time, it is necessary to be critical of what information Jorunn actually received and how she acted.

In the episode H3, four boys participated in the learning activity, and the episode is taken from the last part of the conversation, which is linked to the last clue 1d (in the Figure 2).

260	Hilde:	Then there's one clue left, boys, are we ready? [the boys nod] In the bookshelf there are three times as many soft and scary dinosaurs as there are soft toys on the bedside table. Wow…
261	Q:	three like that
262	Hilde:	if these are the soft toys [pointing to the pile they made with blocks to represent the soft toys] that are on the bedside table, and you should have

three times as much. [gasps a little] What does it mean when it's three times as much?

263 Q: three times as much

Pupil Q repeated the term with wonder in his voice (line 263), and further in the conversation several pupils tried to explain what they thought.

276 Q: So then I take three again, one, two, three, then I've come to nine.

277 Hilde: It sounds very clever, but it's not three, it's five. And five three times.
[pupils think, and continue working for 2-3 minutes]

278 Q: five [holding up the hand] then to these I have ... I've done it two, ... fifteen!

279 Hilde: Fifteen! Oh, we have to make the last fifteen, you guys are ready?

Hilde confirmed the pupils' work before she told them that they had to start with the amount of five and not three (line 277). She praised the pupil's thinking and repeated the information about the amount with another wording 'five three times'. The *response* from the teacher led the pupils to continue to work. After a few minutes of work, the pupil Q addressed Hilde and explained 'five three times' by showing the amount of five with his fingers on his hand. The teacher responded by repeating the number and urged the pupils to add fifteen blocks to the pile they had made for the number of soft toys in the room. This episode is an example of Hilde's response when pupils worked to explore the concept of three times as much. The teacher let the pupils work on the assignment without interfering with the work process. If the teacher made a conscious choice by allowing pupils to explore the concept with the wrong amount, the choice can be seen in the context of interpreting information about the pupils. It is possible to interpret the episode as an example of Hilde *recognizing* the thinking of the pupils and giving the pupils confirmation of thinking before correcting the amount.

The interviews revealed that both teachers thought of MCs as a way of conducting formative assessment in their mathematics teaching, and especially with young students. It is their most typical and frequent way of conducting FA. They stressed the importance of getting feedback immediately:

> You have to do it /assess/ while they /pupils/ are in the process. ... we can always put a smiley face in the book or something like that, but it kind of does not become what is [pause for thoughts] … yes, in relation to pupils, because they are so much here and now. (Hilde)

> I would say that my practice has changed from being an "after-assessor" to being "along the way". So that I do not spend a lot of time on corrections afterward anymore, because, in relation to primary school, I think it has no sense. They /pupils/ are done. And when they are done, they are done. They do not look at what they did, so I try to put as much weight as possible along the way so they get the feedback as soon as possible. (Jorunn)

Discussion

In this paper we focused on characterization of enactment of FA during MCs. Our findings revealed that both teachers were continuously collecting evidence of pupils' learning by listening, asking

questions, revising the learning goal according to elicited information, interpreting pupils' thoughts, rephrasing their questions, providing time for pupils to think, acting, etc. In other words, they modified teaching in relation to how pupils responded to the learning activity. FA enacted during a MC seems to be a dynamic process, in which its four aspects were interrelated, both in PFA and IFA. FA evolves like a spiral through these aspects, but at the same time back and forth through the aspects. Moreover, there is not always a straight forward process with one action following another, as rendered in Figure 3, which shows the circular characteristics of FA enacted during a MC.

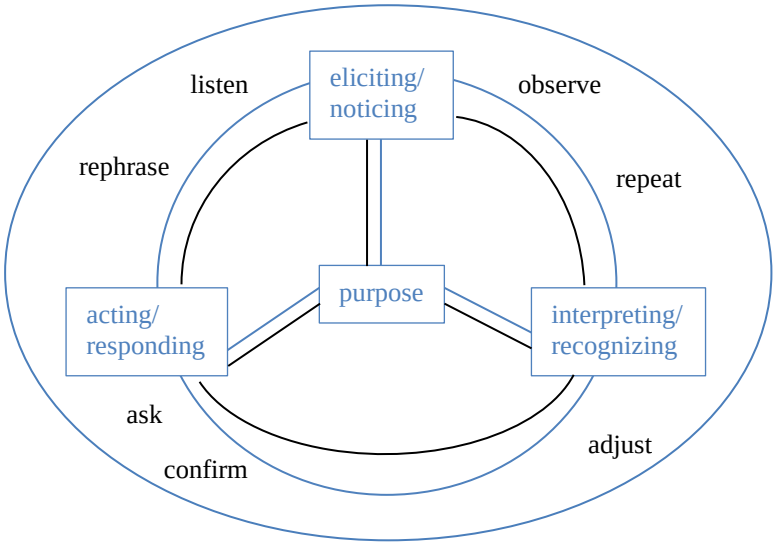


Figure 3: Our model suggestion of FA enacted during a MC, from a teacher's perspective

In Bell and Cowie's study (2002), science teachers indicated that eliciting and noticing were easier to do in the classroom than taking action and responding. Based on our observations, we concur with this finding, as the FA is "a complex, skilled task and it relies on the teacher's pedagogical knowledges" (Bell & Cowie, 2002, p. 92). Bell and Cowie (2002) suggest that "any future teacher development would need to focus on taking action and responding" (p. 94), as this determines whether the assessment is, in fact, formative or not. Bennett (2011) suggests that "to realize maximum benefit from formative assessment, new development should focus on conceptualizing well-specified approaches built around process and methodology rooted within specific content domains" (p. 5). Our study elucidates a MC as a specific way of conducting FA, which is in line with Ruiz-Primo (2011), who argues that assessment situations can occur in almost any learning activity if the teacher is aware of the student's learning. Faced with the new curriculum LK20, with an emphasis on speaking more mathematics, this study stands as an example of how two teachers assess "along the way" ("underveisvurderer") and/or act out FA during MCs. MCs are not FA per se. Our study contributes to the existing knowledge on teachers' FA practices when MC is the dominating teaching strategy.

Notes and acknowledgments:

These results were previously presented in Norwegian, in the master thesis of the first author. The paper was supported by the H2020 project MaTeK, no. 951822.

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