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# **Formative assessment**

## **– in the hands of beginning mathematics teachers**

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*Formative assessment is a key competence of professional teachers, yet complex and demanding to develop. Thus, beginning mathematics teachers (BMTs) cannot be expected to have fully developed this competence. In an ongoing study we examine and depict similarities and differences between four BMTs' use of formative assessment in practice. We will use data from video-recorded observations to analyze to what extent and in what ways the BMTs use five key strategies in formative assessment practice and the main idea of this practice, that is, to use information about students' learning to adjust teaching and learning to the students' needs. The study will provide insight into crucial aspects of formative assessment that BMTs need to learn about and reflect on during and after teacher education. Implications for teacher education are discussed.*

*Keywords: Formative assessment, teacher education, mathematics teachers, beginning teachers.*

### **Introduction**

In this paper we focus on mathematics teachers' use of formative assessment in their early careers, and in particular on aspects of formative assessment especially important for these teachers to be vigilant about and reflect on during and after their teacher education (TE). Formative assessment (also called "assessment for learning") refers to a classroom practice in which assessment is used to identify students' learning needs so that teaching and learning can be adapted accordingly (Black & Wiliam, 2009). The teacher as well as the students can be agents in the processes involved in this practice. The empirical evidence of increased student learning in all school years and subjects (e.g., Black & William, 1998; Hattie, 2009) – including mathematics (Palm et al., 2017) – has led to great attention to formative assessment in education research, policy, and practice (DeLuca et al., 2016). Additional theoretical argumentations further motivate the use of formative assessment in mathematics education (e.g., Schoenfeld, 2020).

The increased interest of using assessment to increase the learning of the students has broadened the concept of assessment beyond using assessment for marking and grading (DeLuca & Bellara, 2013), and assessment competence has become a key competence of professional teachers (Xu & Brown, 2016). Consequently, teachers need to learn about formative assessment in their teacher education (DeLuca & Johnson, 2017; Shepard et al., 2005). They need to learn about why using formative assessment and how to put it in practice. More specific, a use of high-quality formative assessment requires teachers to: understand the purposes of and principles on which this classroom practice is based; have ability to incorporate this classroom practice into their teaching; and to use a critical reflection on aspects of quality relating to their understanding of that practice (Xu & Brown, 2016; Young & Kim, 2010). Because the implementation of high-quality formative assessment is complex

and challenging (Black & Wiliam, 2009) beginning teachers cannot be expected to have reached full competence for such implementation. Rather, their formative assessment competence will develop under the right conditions (De Luca & Johnson, 2017). However, more studies are needed at different levels and with different foci in order gain knowledge about how to design the right conditions and effective support for teachers' development of assessment competence (DeLuca & Johnson, 2017). In this paper we focus on qualitative aspects of formative assessment classroom practice.

More specific, we use the framework by Wiliam and Thompson (2008) to characterize beginning mathematics teachers' (BMTs) formative assessment practices and shed light on aspects that are important for those teachers to be aware of and reflect on during and after TE. With the involvement of the teacher as well as the students in various assessment and learning processes, this framework reflects the complexity of putting formative assessment into practice. The framework consists of the main idea of using information about students' learning to make decisions about how to adjust teaching and learning to meet students' needs, along with five key strategies (KS) guiding the implementation of this assessment in practice:

KS 1. Clarifying, sharing, and understanding learning intentions and the criteria for success

KS 2. Engineering effective classroom discussions, questions, and tasks that elicit evidence of learning

KS 3. Providing feedback that moves learners forward

KS 4. Activating students as instructional resources for one another

KS 5. Activating students as the owners of their own learning

A clear learning goal with specification of what is counted as criteria of success is crucial in all assessment. In formative assessment the sharing of learning goals and success criteria (KS1) is essential for the feedback processes between the agents (teacher and students) involved in the formative assessment processes. A clear learning goal facilitates eliciting the relevant information about students' learning needs (KS2) and providing adapted instruction, that include teacher feedback (KS3), that move students' learning forward. In addition, a clear learning goal and success criteria are decisive for peer assessment and peer feedback (KS4), and for self-assessment with subsequent adjustments (i.e. self-regulated learning, KS5). Thus, this framework can be used to analyze and characterize qualitative aspects for each KS, as well as the integrated use of them to fulfil the main idea of formative assessment.

In a previous case study, we used the above-mentioned framework to characterize one mathematics teacher's development of formative assessment competency during and after TE. We recognized that the teacher during this time made incremental changes, however crucial for the formative assessment processes in the classroom. That is, the changes enhanced the possibilities for the teacher to gain insight into students' thinking, which is crucial for decisions-making about what feedback to provide the students and/or about adaptations of other learning conditions to meet the needs of the students. This insight about how a seemingly small change makes a big difference in formative assessment processes made us interested in comparing BMTs' formative assessment practices. An assumption is that comparing the way the BMTs use formative assessment will gain insight into aspects that are

important for BMTs to learn about concerning the purpose and complexity of the use of formative assessment. Such aspects will be significant for early career mathematics teachers to evaluate their understanding and need of development. The insights will also be useful in teacher education when preparing BMTs for the development of formative assessment competence. Moreover, researchers may be inspired to study what variables that affect putting these aspects into practice, circumstances that help mathematics teachers implement those formative assessment aspects, and obstacles the teachers need to overcome to be able to use high quality formative assessment.

## **Aim and research questions**

In the study we examine and depict the similarities and differences in four BMTs' use of formative assessment in their classrooms. The aim of the study is to identify aspects of formative assessment that are important for mathematics teachers to become aware of and reflect on. The study is guided by the following questions: To what extent and in what ways are the five key strategies used in the BMTs' classroom practice?; What are the similarities and differences between the four classroom practices?; and What do those similarities and differences mean from the view of the purposes and principles of formative assessment?

## **Method**

### **Informants and data**

The data used in the study comes from a project called TRACE<sup>1</sup> in which student teachers in their last year of mathematics teacher education at two Swedish universities were asked to volunteer as participants. The informants received information about the study and ethical aspects, and written consent was obtained before data collection began. Due to the 2020 Covid19 pandemic restrictions the data collection was interrupted. In this study we use data (video-recorded classroom observations) from the four informants that were possible to trace more than one year after their graduation. These informants participated in the same teacher program at the same university in Sweden. They graduated with a teaching degree, grades 7-9, with mathematics as specialization. The teaching being observed is also from mathematics lessons in grades 7-9. Three lessons per informant are observed. Gry and Elvin (fictive names) graduated in January 2017. They were observed in October 2018. Tina and Anton (fictive names) graduated in February 2018. They were observed in September 2019.

### **Analysis**

In the analysis we use the framework by Wiliam and Thompson (2008, see above), and draw on previous research experiences of developing and using an analytical tool based on this framework (Andersson et al., 2017; Andersson & Erixon, in press). This means that we use a previously developed tool at start, yet prepared to adapt or complement the coding manual whenever needed. The main codes are: transparency of the learning goals and success criteria (KS1); elicitation of information about student learning (KS2); teacher feedback (KS3); feedback between students (KS4); and students' regulation of their own learning (KS5). For each main code a number of initial subcodes

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<sup>1</sup> TRACE project founded by The Swedish Research Council, project/grant number [017-03614]

are set. During initial coding these subcodes are customized to the data so that all lesson activities related to formative assessment are identified and coded. A selection of subcodes is presented in Table 1. These are exemplified in the preliminary findings. We limited the presentation of the process of categorization due to the limited space in this paper. Our analysis is qualitative, but we count some frequencies in our data. This is not because we will try to generalize our result, rather the reason for examining the frequencies is to understand qualitative differences. For example, we compare the extent the informants use different feedback types, by counting numbers and calculating their use as if the lessons were equally long.

**Table 1: Subcodes for each main code**

Main Code	Subcodes	Main Code	Subcodes
KS1	Explicit formulated learning goal	KS3	Confirming the answer as correct or acceptable
	Goal of doing		Repeating or reformulating what the student said
KS2	Questions about how and why		Explaining (often by simplifying or deepening)
	Questions that require a short answer, yes/no		Initiating mathematical reflection on the solution process
	Assessment material		
KS4	Nothing has been found so far	KS5	Nothing has been found so far

As a last step of the analysis, we will examine the similarities and differences from the view of the purposes and principles of formative assessment. In this step we will consider both the purpose and principles for each KS and their integrated use. This step has not yet started systematically, but we provide one example in the preliminary findings below. Both authors are engaged in data analysis to ensure reliability.

### **Preliminary findings**

Below we present some preliminary findings, with a focus on the similarities and differences in the BMTs' use of the five key strategies. The findings will later be complemented with narratives to contextualize the formative assessment activities each teacher uses. Moreover, an overview of similarities and differences will be presented along with concrete examples. Finally, the findings from analyzing the similarities and differences from the purposes and principles of formative assessment will be presented (one example regarding teacher questions is now included below).

#### **The transparency of the learning goal (KS1)**

We have identified three ways of presenting the goal of the lesson: As a learning goal, what students are going to work with, and what pages or tasks to finish. Gry referred about twice as often to the learning goal as the other teachers. For example, she presented the goal as follows:

Gry: Do you know what a polynomial is? We are going to talk about what a polynomial is.

Gry also referred to the mathematical content when she presented the goal of the lesson as something the students are going to work with:

Gry: There are polynomials of degree one, and we have worked with first degree polynomials recently. We are soon going to work with second degree polynomials.

Elvin, however, in most cases presents the goal of the lesson in terms of what tasks to complete, as a goal of doing:

Elvin: Solve the tasks in chapter 1.6.

### **Elicitation of evidence of learning (KS2)**

We were not able to confirm that the evidence of learning that the teachers elicit actually was used to adjust the teaching and/or learning in the classroom. Thus, we treat the KS2-activities as potentially being formative assessment activities. As example, all teachers referred to written tests. A difference was found regarding their use of questions, in terms of what types of questions they used.

Anton and Tina asked a lot of questions that only required short answers. In comparison with Elvin they asked such questions about seven times as often as he did. Gry asked questions about the mathematical content about twice as often as Elvin. About 62% of questions Gry asked could be answered with a yes or a no:

Gry: This became very theoretical, right?

For Gry, the remaining questions (38%) were about what and how, and the students needed to explain to answer them:

Gry: Why is this a polynomial of degree one?

In addition to these activities we could identify that Elvin and Tina used “exit-tickets” to assess what the students have learned during the lesson. Tina introduced the exit-ticket to her students as follows:

Tina: Before you go just so I can see what I have done and what you have learned [...] the question is What have you learned? What do you need to develop based on this lesson?

### **Teacher feedback (KS3)**

Also regarding feedback there were differences between the teachers. Elvin used feedback much more often than Gry and Tina did. Four types of feedback dominated. Two of them regard the correctness of student response: feedback confirming the answer as correct or acceptable, and feedback repeating or reformulating what the students said. The other two were: feedback to explain, and feedback to initiate mathematical reflection on the solution process. Elvin and Tina used the last two types of feedback when elaborating on tasks and/or examples that the students found hard to understand. Gry stood out, she did not use the last type of feedback at all. Below quotes will exemplify the different types of feedback:

Example of feedback to confirm the answer as correct:

Student: Well, the square root of 2600.  
Elvin: Yes.

Example of feedback to repeat or reformulate:

Student: Can you round to 51?  
Elvin: A question from [the name of the student], can you round to 51?

Example of feedback to explain:

Elvin: She converts to centimeters and then she divided by the growth per month, the number of centimeters divided by how much it grows per month.

Example of feedback to initiate mathematical reflection on the solution process:

Elvin: Then we have factorized, can you factorize further?

Moreover, Elvin stood out in another respect. He used a fifth type of feedback, that is, answering questions from the students. He used such feedback about six times as often as the other BMTs:

Student: Can you show another one, so that you have to think a little differently. Like this 327, or any number that you cannot factorize prime numbers?

Erik: Yes, some numbers cannot be factorized in prime numbers, for example 11.

#### **Feedback between students (KS4)**

Both Tina and Elvin encouraged the students to work in smaller groups or in pairs so that they could discuss and help each other with the tasks. Nevertheless, there were no examples of how the teachers actually supported their students to be able to assess and provide feedback to each other.

#### **Students' regulation of their own learning (KS5)**

Nothing has been found so far.

#### **From the view of the purposes and principles of formative assessment – one example**

The questions the BMTs used during the lessons show qualitative difference from the perspective of providing the teacher with useful information to adjust learning activities and providing feedback. The questions that can be answered with a yes or a no are less useful than questions where the students need to explain their thinking. The BMTs used such question to different extent.

#### **Discussion**

In this study we aim at identifying aspects of formative assessment that are important for mathematics teachers to be vigilant of and reflect on during and after their TE. Compared to the previous study – where we focused on the development of formative assessment competence of mathematics teachers in early career – this study has a stronger focus on what it means and what it takes to implement high quality formative assessment (see Xu & Brown, 2016; Young & Kim, 2010). When all findings are in place, we will be able to make conclusions about what aspects of formative assessment that were identified as crucial for beginning mathematics teachers. We will then discuss how formative assessment was used by the BMTs; the similarities and differences; what those findings means from the perspective of the purposes and principles of formative assessment; and implications for teacher education. The discussion below is restricted to the preliminary findings.

In all classrooms, the students rarely function as agents in formative assessment processes. This is true for their function as resources for each other (KS4), as well as, for regulating their own learning (KS5). This crucial aspect is also connected to clarifying and sharing learning intentions and criteria of success (KS1). For students to be involved in formative assessment processes, they need an idea

of the learning goal and what constitutes progress in that learning. Moreover, the goal of a lesson is often communicated in terms of what pages or tasks to finish. Thus, another crucial aspect is to not take for granted the students' understanding of learning intentions and success-criteria, and maybe even to examine the students' perception of those intentions and criteria.

The differences between the informants reveal other crucial aspects. The teachers' different ways of using questions have different potential for the teacher to receive sufficient information about student learning needs to adjust their teaching and their feedback. Elvin and Tina also stood out by using exit-tickets at the end of their lesson. Regarding feedback, the use of feedback to inform whether the student's thinking is right or wrong can be relevant, but the other types of feedback that were used have higher potential for helping the students to move forward in their learning. The informants' use of feedback to initiate reflection on the solution process and Elvin's feedback answering students' questions, both reveal a crucial aspect about how to get the students involved in feedback interactions. This aspect also includes that the students can be involved in a high-quality way – exemplified by Elvin's student, who asks a specified question that both reveals his learning needs and gives the teacher the opportunity to give effective feedback.

All together, we identified six crucial aspects: Do the students function as resources for each other (i) and themselves (ii)? Does the learning goal surpass the goal of doing and how do the students perceive the learning goal and criteria of success (iii)? Is the information about student learning sufficient (iv), what feedback did actually support students' learning (v); and in what ways are the students involved in feedback interactions (vi)?. We expect to find additional crucial aspects, including aspects that concern the integrated use of the key strategies.

## **Implications**

Implications for TE regard aspects are related to requirements to high-quality formative assessment practice. First, BMTs need to be aware of the importance of having information about students' learning needs and consequences of not having such information, as well as what potential is inherent (or not) in different feedback types (i.e. understand the purposes of and principles on which this classroom practice is based). Second, they need to know what to do when they experience not having enough information and how to decide whether their feedback was helpful and what to do if their feedback was unsuccessful in helping the student (i.e. have ability to incorporate this classroom practice into their teaching). Furthermore, the BMTs need to use a critical reflection on these aspects of quality relating to their understanding of formative assessment practice.

## **Limitation**

In this study the informants participated in the same program at the same university. Possibly, the differences in classroom practice would have been even larger if the informants came from different programs and universities. Another concern is that we will not be able to identify all kind of activities related to formative assessment when only using video-recordings of lessons. We will only be able to identify direct observable activities and phenomena. Regarding both limitations, we believe that – building on the findings from the present study – future studies can find complementing crucial aspects that BMTs need to learn about and reflect on concerning their understanding and need of development. We argue that studying the classroom practice using “in practice data” is a good start.



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