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Formative assessment in mathematics teacher education – Perspectives of pre-service teachers in a group discussion

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The article reports the implementation of formative assessment in a pre-service teacher education seminar at a university. The seminar concept is first presented, focusing on two aspects: the process-related competences of pupils and the strengthening of the situation-specific skills of the pre-service teachers. The use of formative assessment itself was the object of an accompanying qualitative study, and the pre-service teachers of the seminar were interviewed in a group setting. They reported their experiences with formative assessment, advantages, and disadvantages, and transferred this to their later school practice.

Keywords: Formative assessment, situation-specific skills, teacher education, pre-service teacher.

Introduction

Black and Wiliam (1998b) established the positive effects of formative assessment on student learning. However, teaching teachers how to implement formative assessment effectively has been challenging, as many teachers struggle to use it regularly in their classrooms (Black & Wiliam, 2003). This dilemma raises the question of how to promote formative assessment among teachers. One possible solution could be to provide pre-service teachers with hands-on experience in formative assessment during their university education. This experience might increase their understanding and appreciation of formative assessment.

This article presents a seminar concept for strengthening the situation-specific skills of pre-service teachers concerning the development of the pupils' process-related competences by implementing formative assessment in mathematics education. Additionally, accompanying research is presented to address the following research questions:

- (1) What perspectives do pre-service teachers have towards formative assessment in a mathematics education seminar?
- (2) How do pre-service teachers deal with feedback in a mathematics education seminar?
- (3) What perspectives do pre-service teachers have towards formative assessment in mathematics at school?

Theoretical background

Teachers' situation-specific skills

Teachers' perception, analysis, and interpretation of complex teaching situations are considered a prerequisite for appropriate teacher action. The training of teachers in these skills is already substantial during their university education, whereby the use of video-based concepts is relevant in this regard (Blömeke, 2013). The ability to perceive, analyze, and interpret complex teaching

situations relates to the construct of teacher noticing, which has increasingly become the focus of research on a national and international level in recent years due to its relevance for the professional actions of teachers (van Es & Sherin, 2010). As one of the first researchers, Goodwin (1994) points to a profession-dependent perception of noticing, which is why Sherin and van Es (2009) understand the professional perception of teachers as the "ability to notice and interpret significant features of classroom interactions" (p. 22). Noticing is now an integral part of competence models, such as in the model by Blömeke et al. (2015), which explicitly identifies "perception" as a sub-process of the situation-specific skills of teachers (see Figure 1).

Perception, interpretation, and decision-making link teachers' professional knowledge to observable behavior through which the connection between teachers' cognition and affective-motivational beliefs (dispositions) and their teaching behavior (performance) is emphasized, and competence is considered as a continuum (Blömeke et al., 2015; see also Stahnke et al., 2016).

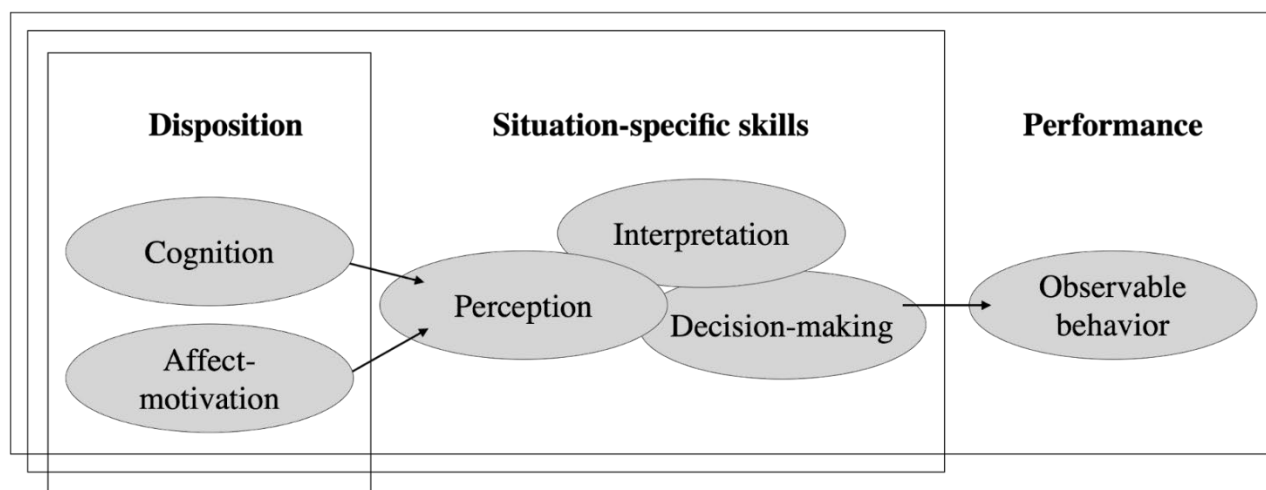


Figure 1: Competence as a continuum (based on Blömeke et al., 2015, p. 7)

Van Es and Sherin (e.g. 2002, 2010) have researched how teachers' situation-specific skills can be promoted. They examine the use and effect of videos to develop professional perception (van Es & Sherin, 2002). On the one hand, they developed a Video Analysis Support Tool (VAST) for analyzing videos, e.g., concerning learners' thinking, with VAST positively influencing the trainee teacher's ability to analyze (van Es & Sherin, 2002). On the other hand, another research approach by van Es and Sherin (2010) is the implementation of so-called video clubs for the joint analysis and discussion of instructional videos with a moderator. The video clubs' work also positively influences professional perception, in that, among other things, more detailed interpretations of the learners' mathematical thinking are made (ibid.). These research results show how noticing can be supported and trained, namely with the help of videos, which can be used to depict complex situations.

Assessment of situation-specific skills

Situation-specific skills are essential for future teachers to succeed in their profession, as they must be able to apply their skills in diverse situations to ensure that their pupils receive a high-quality mathematics education. Assessing these skills is critical in pre-service teacher education because it can ensure that pre-service teachers are adequately prepared to meet the demands of their future roles

and develop and enhance their skills over time. A distinction is made between summative and formative assessment: Summative assessment is mostly about grading at the end of a learning unit at school or the end of a course at university, for example, through a written or oral exam (Brookhart, 2010; Cizek, 2010; Gikandi et al., 2011; Sadler, 1989). On the other hand, the formative assessment takes place parallel to the learning unit or course to support the learning process and improve individual learning (Brookhart, 2010; Cizek, 2010; Gikandi et al., 2011).

There are several advantages of formative assessment for pre-service teachers in the university. One is enhanced learning because formative assessment allows pre-service teachers to receive timely feedback on their progress, which can help identify areas where they may be struggling and provide opportunities to improve their learning (Black & Wiliam, 1998a). This can lead to enhanced learning outcomes and a deeper understanding of the subject matter. Furthermore, it improves teaching practice since formative assessment provides pre-service teachers to practice their teaching skills and receive feedback from their peers and instructors (Darling-Hammond & Bransford, 2005). This can help them to develop their teaching practice and become more effective educators. In addition, it increases engagement, as formative assessment encourages pre-service teachers to be more engaged in learning as they actively monitor and evaluate their progress (Black & Wiliam, 1998a). This promotes a sense of ownership and responsibility for their learning. Another advantage is personalized instruction because formative assessment allows instructors to identify individual pre-service teachers' strengths and weaknesses and provide personalized instruction to meet their specific learning needs (Wiggins, 2012). This helps ensure that all pre-service teachers receive the support they need to succeed. Also, it leads to continuous improvement since formative assessment provides pre-service teachers with ongoing opportunities to reflect on their learning and teaching practice and make adjustments as needed (Hattie & Timperley, 2007). This can help them to improve and refine their skills over time continuously. Finally, Heritage (2007) has found that teachers need the right attitude toward formative assessment or will not use it in classrooms. To help teachers develop this attitude and encourage them to use formative assessment themselves in later classrooms, it could be essential to let them experience it firsthand at university.

Implementation of formative assessment in a pre-service teacher seminar promoting situation-specific skills

Design of the seminar

In the winter of 2022/2023, a hybrid, didactic Bachelor's seminar was offered for eleven special education pre-service teachers at the University of Cologne. Before this seminar, the pre-service teachers had already attended one mathematics education lecture and two mathematical lectures with exercises. All of them visited the seminar for the first time. The seminar was based on two pillars:

One pillar concerned the creation of a theoretical background (Cognition) concerning general mathematical competences. These so-called process-related competences were formulated as acquired competences in the German Educational Standards and include mathematical arguing, mathematical communicating, presenting mathematics, problem-solving, and modelling (e.g. KMK, 2022). On the one hand, these competences can be developed by processing mathematical tasks; on the other hand, they can be activated and used by the pupils. Acquiring process-related competences

is crucial for successfully using and acquiring mathematics skills (ibid., see also Geisen & Vogtländer, 2021). Therefore, teachers must create opportunities in their mathematics lessons where pupils can apply and utilize process-related competences for effective mathematical learning (Walther et al., 2012). Therefore, current literature dealing with the various competences, was used in the seminar, which the pre-service teachers had to work through and process methodically in different ways. For example, the pre-service teachers had to work in groups to develop a podcast that dealt with the relevant aspects of mathematical communication of learners.

The other pillar aimed at promoting perception, interpretation, and decision-making (situation-specific skills) because the perception, as well as the analysis and interpretation of complex situations by teachers, is considered a prerequisite for appropriate teacher action. The training of teachers in these skills is already substantial during their university education (Blömeke, 2013), wherefore videos can be used (van Es & Sherin, 2002; 2010). For this purpose, video vignettes showing pupils in school working on tasks were used in the seminar (Geisen, 2021). For example, the pre-service teachers perceived, analyzed, and interpreted possible difficulties of pupils regarding the competence of modelling based on such vignettes. Finally, based on their analyses and interpretations, the pre-service teachers considered how to continue working with the pupils in mathematics lessons.

During the seminar, a total of six tasks had to be submitted by the pre-service teachers, whereby the submissions referred to two video analyses, but further video analyses took place. These edits were analyzed in terms of formative assessment, and the pre-service teachers received individual written feedback from the lecturer. Table 1 gives an overview of the content, methods, and goals.

Table 1: Contents and methods of the six submitted tasks in the seminar

Content	Method	Goals
Dealing with contemporary mathematics lessons concerning process-related competences	Quiz with free answer fields	Development of an understanding of contemporary mathematics education and the relevance of process-related competences
Developing mathematical communicating and reflecting on this concerning a need for special educational support	Developing a podcast	Development of theoretical background and linking mathematics didactics and special education
Developing mathematical arguing and reflecting on this concerning a need for special educational support	Developing a poster	Development of theoretical background and linking mathematics didactics and special education
Video analysis for mathematical communicating and arguing	Writing an elaboration	Strengthening perception, analysis, and interpretation concerning teaching
Analysis of problem-solving tasks with regard to cognitive requirements and possible difficulties	Writing an elaboration	Strengthening task analysis concerning lesson preparation
Video analysis for modelling	Writing an elaboration	Strengthening perception, analysis, interpretation, and decision-making concerning teaching

Objectives, method, and sample

The seminar addressed the strengthening of the pre-service teachers' situation-specific skills. In addition, the concept of formative assessment was particularly suitable for a competence-oriented review of the learning process. However, since this form of examination is used less frequently at universities than summative forms in Germany, the question arose of how pre-service teachers felt about this assessment form, which was addressed in a group discussion (Bohnsack, 2000).

The group discussion is a method of qualitative social research in which several participants can be interviewed simultaneously (ibid.). The aim is to determine the participants' opinions on a specific topic by using open questions and allowing them to stimulate each other. A guide will be developed in advance for structuring and standardization. The discussion is recorded and evaluated qualitatively (Mayring, 2015). The group discussion is ideal for investigating the research questions concerning formative assessment in a seminar for pre-service teachers at the university.

As part of the seminar, eight of eleven pre-service teachers took a voluntary part in the group discussion at the end of the semester, three females and five males.

Results

(1): Formative assessment in mathematics education

The pre-service teachers described their mathematical learning as an active, sustainable, and long-term process. They found the continuous and especially individual feedback motivating, one stated that, "the feedback motivated me to submit something every week." Moreover, they distinguished feedback of formative assessment from feedback of summative assessment. They saw formative feedback as a more significant opportunity for self-reflection and improvement. The pre-service teachers mentioned the keyword "anonymity" in the summative assessment of mathematical lectures and exercises but felt individually "seen" in this seminar, some students said "for the first time, I felt that I was getting honest feedback. (...) Otherwise, it was just a sample solution. (...) I usually didn't get along with it very well." and "getting this kind of feedback on stuff is rare, so rarely actually." The pre-service teachers particularly appreciated that the lecturer took the time to give feedback and was the direct contact person for questions, as the students stated "in math, we always had these exercise sheets. Then getting a right or a wrong, not getting into an exchange at all, why is it wrong, why is it better that way." and "normally, it is only right or wrong, no explanation." According to the pre-service teachers, this created a good relationship of trust. In addition, the pre-service teachers appreciated the feedback and saw the formative assessment as an opportunity to adapt the mathematical teaching to their needs.

(2): Dealing with individual feedback in mathematics education

All pre-service teachers stated that they had read the individual feedback on the mathematics education tasks in the seminar. In doing so, they referred in particular to the clarity and comprehensibility of the feedback. They emphasized that not only criticism was expressed, but also positive aspects regarding the processing. The pre-service teachers did not further reflect upon such positive feedback. However, suggestions for revision and stimulating questions were reflected by the pre-service teachers based on their edits, and "mental" revisions took place, for example students

said, “Stimulating questions were included in the feedback. I found that really good. It made me think about it again.” and “After reading the feedback, I thought about the task and my solution again and reflected on it. What would have been better?” No student made any written revisions.

(3): Formative assessment in mathematics at school

All pre-service teachers emphasize the potential of formative assessments in terms of learning process support and learning success and feel that individual feedback for the pupils in mathematics lessons is desirable, for example: “I would love to do that at school too.” and “This is something I can very well imagine, what I would wish for.” In particular, they emphasize the possibility of constant adaptation to the needs of the learners. Pre-service teachers perceive class work as an unreliable instrument for continuous documentation of the mathematics learning process. Individual feedback would enable pupils to improve, strengthen their self-confidence and create trust in the mathematics teacher. However, all pre-service teachers see difficulties with implementing formative assessments in mathematics lessons, for example, due to many pupils in a class or due to the heterogeneity of the pupils, students stated that “Doing that always is utopian, but now and then is possible.” and “It’s good, but I see the following problem: In inclusive settings, when you have 32 students sitting there (..) I just don’t have the time.” Furthermore, they were concerned with the increasing workload. Therefore, the pre-service teachers discussed verbally instead of written feedback and feedback for group work as possible solutions.

Summary and conclusion

The results of this study demonstrate the pre-service teachers' positive perspectives towards formative assessment in mathematics education, an effect maybe enhanced by the use of video clubs (van Es & Sherin, 2022). The pre-service teachers found the continuous and individual feedback motivating and appreciated the opportunity for self-reflection and improvement in mathematics education, which is in align with the previous research e.g. Brookhart (2010), or Cizek (2010). They also recognized the potential of formative assessment in school to support the mathematical learning process and improve learning success. However, they highlighted difficulties in implementing them due to class size and heterogeneity. The pre-service teachers participating in the group discussion felt that formative assessment increases their future workload in mathematics at school because it requires more time and effort to provide individual feedback, something in-service teachers has reported as reasons not to use formative assessment in school, although they know about the benefits (Black & Wiliam, 2003). The teachers’ perspective towards formative assessment is essential to its implementation, as it can impact their workload in school (ibid.). The fact, that the pre-service teachers have the same perception of the workload than the in-service teachers gives hint, that the pre-service teachers practised their situation specific skills (Darling-Hammond & Bransford, 2005). However, research suggests that teachers can effectively manage their workload by incorporating formative assessment into their regular teaching practice (Bloxham & Boyd, 2007). By using online tools or peer assessment, teachers can reduce the time and effort involved in providing feedback. Peer feedback could also be incorporated into another run of the presented seminar so that the pre-service teachers also practice giving feedback (Ayalon & Wilkie, 2021). Using formative assessment practices allows for immediate feedback and adjustment, ensuring that pre-service teachers receive ongoing support

to improve their perception skills, which is an essential step towards a profession as a future teacher (Goodwin, 1994). The combination of formative assessment and video-based teacher training (e.g. video clubs, Van Es & Sherin, 2010) might provide a powerful tool to support the development of future teachers' situation-specific skills (Blömeke, 2013).

Overall, the findings of this study suggest that formative assessment in combination with video-based training can enhance pre-service teachers' mathematical learning, improve the quality of mathematical teaching, and provide valuable insights for future research and practice in this area. In addition, formative assessment could be used in other mathematics (education) seminars.

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