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Enhancing future teachers' situation-specific modelling competencies by using staged videos

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Although discussed frequently, there is still a gap between theory conveyed at university and the teachers' practical work at school after finishing their degree, which can lead to the problem that new teachers do not act based on theoretical constructs although they know about them. The paper describes an innovative project, which aims at tackling this problem and fostering teachers' situation-specific competencies by helping future teachers making their knowledge applicable. Therefore, staged video vignettes are created to support future teachers episodic memory through repeated practice with videos, which simulate real classroom situations. This theoretically informed paper focuses on identifying criteria for staged video vignettes based on the concept of teacher's expertise in mathematical modelling, using those when creating video vignettes and implementing them in an innovative learning environment.

Keywords: Mathematical modelling, teachers' situation-specific competencies, teachers' expertise, video vignettes, staged videos.

Introduction

In the last decade a great number of small-scale as well as a few large-scale studies in the field of mathematics education have focused on teachers' expertise (e.g., large-scale studies: TEDS-M, see Blömeke, Kaiser, & Lehmann, 2010; COACTIV, see Kunter, Baumert, & Blum, 2011). These studies focus on conceptualizing the teacher's knowledge and observe their performance in comparison. However, there exists a gap between knowledge and performance, which is addressed by Blömeke, Gustafsson, and Shavelson (2015) in their PID-model. Their conception of competence as a continuum consisting of dispositions (knowledge and an affective-motivational component), situation-specific competencies and performance suggest a greater relevance of situation-specific skills for the teaching profession. In an innovative project at the University of Hamburg these situation-specific skills are enhanced by the intensive use of videos during a master seminar for future teachers, which deals with the content of mathematical modelling. This paper will describe the development of criteria for staged video vignettes in a theoretically informed approach and the usage of the thereby developed video vignettes during a modelling seminar.

Teachers' professional competencies

As mentioned above this project especially pays attention to the situation-specific competencies as a mean to bridge the gap between theory and practice. A close connection of theory and practice according to the concept of *practice transfer* is aimed at through the analysis of video vignettes. Prenzel (2010) defines transfer (based on studies by Messner, 1978 & Renkl, 1996) as the implementation of a solution developed or knowledge acquired in situation A to another situation B. Effectively solving the problem in situation B means the transfer was successful. Nölle (2002) suggests that professional competence can only be improved through broad knowledge as a basis

but also through episodic experiences. Apparently, a categorical system of knowledge combined with episodic elements is required for the useful application of knowledge and favours a differentiated perception of teaching (Nölle, 2002).

A model, which covers all aspects of teachers' expertise, namely knowledge as well as the skills needed to transfer knowledge into action (called situation-specific skills¹) and the observable behaviour, was developed by Blömeke et al. (2015). The so-called PID-model (see Figure 1) combines the analytic view on teachers' competencies, which analyses teachers' dispositions in all its aspects (knowledge and affective-motivational components), with the holistic view, which focuses on the teacher's performance. The situation-specific skills serve as a link between dispositions and performance and can be distinguished in the professional perception of a teaching situation, the interpretation of the perceived situation and the decisions made, which are based on the interpretation. For this project, the PID-model is used as a theoretical basis.

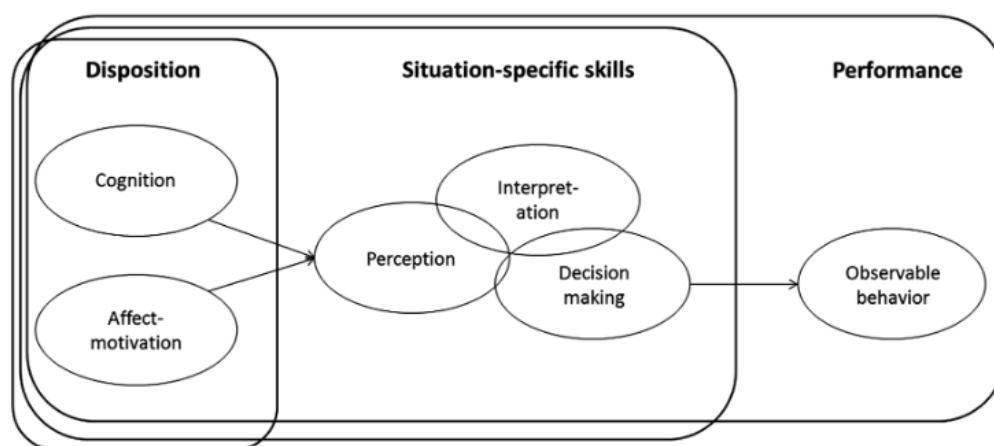


Figure 1: Competence as a continuum (Blömeke, Gustafsson, Shavelson, 2015, p. 7)

The PID-model describes general teaching competencies but can be applied to specific domains as well. However, in every domain certain knowledge and concepts are required. For teaching mathematical modelling specifically, there exists little research on what exactly is needed to foster students' modelling competencies. Mathematical modelling is a complex task for students, because it demands a lot of cognitive work. Thus, supporting students during their modelling process is also a major challenge (Blum, 2011).

Borromeo Ferri and Blum (2010) developed a model, in which they divided teacher's pedagogical content knowledge (PCK) regarding modelling in four dimensions:

- (1) a theoretical dimension (incl. modelling cycles or aims and perspectives of modelling as background knowledge),
- (2) a task dimension (incl. multiple solutions or cognitive analyses of modelling tasks),
- (3) an instructional dimension (incl. interventions, support and feedback), and
- (4) a diagnostic dimension (incl. recognising students' difficulties and mistakes). (Blum, 2015, p. 89)

¹ The ability to notice and interpret remarkable situations in the classroom is also known as *professional vision* (cf. among others Goodwin (1994) or Seidel and Stürmer (2014)) or as *noticing* (cf. Van Es & Sherin (2002)).

Blum (2015) also highlights that a transfer from knowledge into actions cannot be expected automatically. Supporting teachers in applying their knowledge, which is based on Borromeo Ferri and Blum's four dimensions, is therefore an important aim of this project.

Furthermore, Blum (2015) summarizes ten important characteristics for adequately teaching mathematical modelling based on the concepts of quality mathematics teaching. Besides the principles named above, he mentions an "effective and learner-oriented classroom management", providing a variety of examples and exercises for different real-world and mathematical contexts, encouraging multiple solutions, supporting students' positive beliefs and attitudes towards modelling and using digital tools as an aid.

Moreover, in a study evaluating the modelling seminar university students mention the importance of interventions and the wish to deepen their knowledge and practical skills in this area (Vorhölter, 2018b). As shown in various studies, a crucial tool in supporting students are strategic interventions, which are already mentioned in Borromeo Ferri and Blum's third dimension as PCK. In his study with a focus on the procedural aspect Leiß (2007) points out the importance of strategic interventions to support students' independent modelling process. Stender and Kaiser (2015) discover similar findings adding that strategic interventions can only take place if the teacher is trained in this special field. This is based on the Zech (2002) taxonomy of assistance, which categorizes interventions from minimal help such as motivational interventions to content-related interventions.

Besides, enhancing students' metacognitive-strategies is essential as shown by various studies (for an overview see Stillman, 2011). Metacognitive strategies are needed to independently overcome problems during the modelling process and a lack of these will most probably lead to considerable problems (Vorhölter & Kaiser, 2016). Therefore, teachers need to promote cognitive but also metacognitive strategies.

For overcoming the gap between theory and practice, staged videos can be used during teacher education. According to Oser, Heinzer and Salzmann (2010) videos are situation-specific, authentic, complex and context-bound, which makes them the closest tool to imitate real classroom situations. Thus, the substantive aspect of construct validity (Messick, 1995), which is defined as measuring the cognitive processes of competence as close as possible to the theoretical construct, is met. In a meta-analysis of studies regarding the use of videos in teacher education Coles (2014) summarizes that positive effects can be found when "engaging in a process that makes evaluative discourse unlikely" (Coles, 2014, p. 271). Therefore, it is important to explicitly focus on details and their interpretation when watching video clips in contrast to judging the behaviour of students and teachers in the video.

Concept of the modelling seminar

The University of Hamburg offers a modelling seminar during the master's program - usually attended in the first semester-, which every future mathematics teacher gets the chance to attend. The seminar is open for future teachers of primary and secondary school as well as special-needs school and about 30 students attend it every year. Supervising year 9 students during a two-day modelling project is part of the seminar, which aims at enabling future teachers to independently and adequately teach modelling at school in their future job.

The content of the seminar follows the model by Borromeo Ferri and Blum (2010) and can therefore be divided into four aspects:

1. The *theoretic dimension* is implemented by reflecting and discussing articles regarding the following topics: modelling cycles, goals and perspectives of modelling, students' modelling competencies, beliefs and both heuristic and metacognitive strategies. With different methods knowledge about these topics is gained and practiced using worked examples by school students.
2. To acquire knowledge in the *task dimension* the university students have to solve complex modelling tasks themselves and discuss the appropriateness of different solutions including the three tasks they have to supervise during the modelling days. Furthermore, modelling tasks are analysed concerning their demands and difficulties.
3. The *instructional dimension* is discussed by planning the modelling days, e.g. preparing and reflecting the structure, the introductory phase and especially appropriate interventions, which support independent student work.
4. To address the diagnostic dimension, the university students analyse past students' posters presenting their work and identify difficulties and obstacles.

The seminar concludes with the modelling days at school, where the gained knowledge can be implemented and reflected on. Usually the future teachers work in a tandem to discuss each other's performance and reflect on the success of their interventions (for a detailed description of the modelling days and the role of the university students' see Stender and Kaiser (2015)).

Besides providing declarative knowledge, not only relevant for teaching mathematical modelling but also for other domains in mathematics education, a major focus is the transfer from theory to practice. Due to the university's structure, the future teachers usually do not have hands-on experience with teaching when joining the seminar. Therefore, to support the application of knowledge, videos are used as an import tool to simulate real classroom situations, which will be further discussed in the next section. For a more detailed description of the modelling seminar, see Vorhölter (2018b). The transition between theory and praxis is an ongoing process including knowing theoretical constructs, implementing them and reflecting on experience to deepen those theoretical constructs. Group discussions during the seminar regarding university students' video analyses as well as self-reflections on the modelling days in the context of a final assessment also allow them to refer empirical knowledge back to theoretical constructs.

Developing criteria for staged videos

A previous evaluation of the modelling seminar shows that the theoretical knowledge was not perceived as relevant for the university students when teaching at school and could not be translated into practical and usable knowledge in a satisfactory manner (Vorhölter, 2018b). To help them make their knowledge applicable videos will be used as stimulation of the reality. As video recordings usually contain distracting background noises, show long stretches of irrelevant behaviour and sometimes do not catch the students' material or facial expressions, we aim at creating staged videos based on authentic situations found in the original recordings.

To create videos, which show typical situations during a modelling process relevant for future teachers on the one hand, but also limit the amount of irrelevant and time-consuming information

on the other hand, a cyclic process characterized by various revisions took place. First, recorded lessons were used to identify relevant situations. These were developed during the project MEMO (Vorhölter, 2018a), which includes 2 fully recorded lessons of over 50 small groups of students each time, in which mathematical modelling takes place. Only a few of the original recordings could be used due to their length and the great number of distractors.

Therefore, a script was written based on teachers' required modelling competencies and students' typical mistakes regarding modelling. These aspects were identified based on the theoretical construct of teacher expertise in modelling. The script empathizes relevant aspects in order to make them noticeable without being in the context of the lesson in real-time. Important aspects were:

1. Each video shows a different *phase of the modelling cycle*, which can be expected to be recognized. Different phases generate different problems and are therefore crucial for a diagnosis.
2. Because modelling is a cognitive demanding task, it can lead to *various difficulties and obstacles*, which can be mathematical, group work related, concerning the modelling process in general and so forth. The video vignettes try to address a wide range of these problems.
3. To tackle these problems, sometimes the teacher has to intervene. *Interventions* are part of the video vignettes as well as the request for the viewer to describe his or her own intervention as if he or she were there to support the students during a difficult situation at the end of the video.
4. To overcome problems during the modelling process students not only use heuristic but also *metacognitive strategies*, which can especially be helpful. Different metacognitive strategies such as planning and regulation can be found in the videos.
5. Modelling problems are usually solved in a group. Therefore, heuristic and metacognitive strategies influence the group work process and each member of the group plays a *different role* during the process.

The script created, which considers these aspects, was revised by an expert group, which has already worked with staged videos. Another group of experts in mathematics education afterwards played the role of the students following the script, which was videotaped, and improvised in a second take to adapt the situation to a more reality-based setting. Changes in language as well as in behaviour instructions were made and added to the script. Furthermore, a second revision took place based on expert ratings, where the experts were either specialized in the field of mathematical modelling or in the creation and use of staged video vignettes. Finally, three short videos were made by filming year 9 students, who acted according to the script.

Implementing the developed videos

As described above the university students lacked the ability to implement their theoretical knowledge sufficiently during the modelling days. The project aims at providing an innovative learning environment, which offers the opportunity to practice the implementation of knowledge by using staged videos as well as five extracts of recorded lessons.

Important theoretical constructs are conveyed as described above but also exemplified through the staged video vignettes: The videos are used to practice noticing relevant aspects based on theoretical constructs discussed before in a short time. Furthermore, the following discussion and reflection in plenum can lead to a better understanding of the lesson shown and improve the

perception and interpretation of the next video. Moreover, decision-making is required when evaluating the possible interventions at the end of the video. The repeated use of these videos with different content and various modelling-specific problems is sought to lead to a better application of knowledge. This will become clear during the last part of the course, where the future teachers supervise students at school during a two-day modelling project and can implement their knowledge and skills in their performance.

Looking ahead

Making knowledge applicable is an important aspect in teacher education. This innovative project, which uses videos during the described modelling seminar to foster future teachers' perception, interpretation and decision-making, is embedded in a study evaluating the development of teachers' situation-specific competencies and its underlying dispositions as well as the consequences with a mixed methods study design.

Hence, video vignettes serve a dual purpose: Staged videos as well as recorded video clips are used during the modelling seminar to enhance situation-specific competencies. Furthermore, staged videos are used in a pre-post-test design to analyse the development of situated competencies. The Pre- and Post-test also includes a questionnaire, which assesses through closed and open questions knowledge facets based on the model by Borromeo Ferri and Blum (2010). Therefore, the effect of knowledge on the situated competencies and the development of both aspects can be examined. During the modelling days a few selected university students are filmed while supervising the students. Thus, their performance can be observed and all aspects of the PID-model can be analysed and possible connections identified.

In the long term, all three staged videos can sustainably be used in the modelling seminar without further effort or may serve as a means for assessment of the university students' development and performance.

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