

Case-based work with classroom cartoon vignettes as a way to explore pre-service mathematics teachers' multi-criterion noticing

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How to cite: Kuntze, S.; Schall, K.; Krummenauer, J. 2024. Case-based work with classroom cartoon vignettes as a way to explore pre-service mathematics teachers' multi-criterion noticing. In: 10th International Conference on Higher Education Advances (HEAd'24). Valencia, 18-21 June 2024. <https://doi.org/10.4995/HEAd24.2024.17108>

Abstract

In classroom situations, mathematics teachers need the competence to notice situation aspects with respect to multiple knowledge-based criteria for being able to optimally support students in their learning. However, even if the body of research into teacher noticing is growing, research on noticing with respect to multiple knowledge-based criteria is still relatively scarce. This study hence focuses on assessing pre-service teachers' multi-criterion noticing by means of classroom situation vignettes. In particular, the design of vignettes in cartoon format affords balancing out the requirements of situation authenticity and multiple criterion relevance. Correspondingly, a set of such vignettes was designed with built-in analysis needs related to multiple criteria and was used for assessment. The results point to professional development needs, as most pre-service teachers only focused on a rather low number of analysis criteria. Case-based work with knowledge-based reflection on classroom cartoons can provide solutions, which are discussed in a concluding section.

Keywords: Multi-Criterion Noticing; Classroom Cartoons; Vignettes; Representations of Practice, Pre-Service Mathematics Teachers, Case-Based Learning

1. Introduction

Case-based work in initial profession-related learning, in particular in the university context, has received more wide-spread attention across disciplines, building on experience in law, medicine, and economics, in particular (e.g. Kaiser, 1983). For mathematics teacher education, the emphasis of case-based learning includes a focus on classroom situations, as these contexts bring high demands in teachers' professional practice: mathematics teachers have to focus on content aspects, the students' (potentially heterogeneous) understandings and learning prerequisites, the presentation of tasks, among many more criteria and situation aspects. For introducing and translating such profession-related requirements into profession-related

learning opportunities in the academic context, so-called *vignettes* can be used as representations of classroom practice (Buchbinder & Kuntze, 2018), e.g. in video, text, or cartoon format. Against the background of findings that video vignettes can bring high cognitive load (Sweller, 1994) in the perception of pre-service teachers in learning contexts (Syring et al., 2015), particularly the cartoon format appears as a very helpful format for designing vignettes, as disturbing context information can be reduced, foci to relevant theory can be strengthened, and meaningful context information can often be represented easily by graphical means (Friesen & Kuntze, 2016). In particular teachers' noticing in the sense of knowledge-based reasoning (Sherin et al., 2011) is a key competence when teachers are faced with classroom situations. The growing body of research in mathematics education has mostly concentrated on noticing related to a single specific criterion area. There is hence a need for empirical research into noticing in the case of *several* potentially relevant knowledge-based criteria. This study addresses this research need and explores pre-service teachers' multi-criterion noticing. The participants were asked to analyse a set of correspondingly designed cartoon vignettes.

We will in the following (1) give insight into the theoretical background of this study, (2) deduce the research aims, (3) describe the design of the study and the methods used, (4) present results, and (5) discuss them in a concluding section.

2. Theoretical Background

From the perspective of mathematics education, the aspect of knowledge-based reasoning is key to the notion of teachers' noticing (Amador et al., 2021; Sherin et al., 2011; Berliner, 1991): For supporting students in learning mathematics, the connection of observations in classroom situations with relevant criterion knowledge from mathematics education is crucial. For instance, when a teacher explanation is unsuccessful, disconnected representations of mathematical objects (Duval, 2006) might be a reason for this, and mathematics teachers should be able to notice this by using the corresponding criterion knowledge when making sense of what they are observing in the classroom situation (Dreher & Kuntze, 2015; Friesen & Kuntze, 2016, 2021). Noticing in this sense hence requires professional knowledge (Shulman, 1986; Kuntze 2012), and when faced with classroom situations, mathematics teachers often will have to check whether specific criterion knowledge from their professional knowledge background fits to an observation in the sense that it can explain what can be observed in the classroom situation. For successful knowledge-based reasoning, teachers thus have to jump back and forth between the sphere of their professional knowledge background on the one side and the sphere of their classroom situation observations on the other side. This process has been described in an analysis cycle model (Kuntze & Friesen 2018, cf. Fig. 1), in which repeated cycles may occur when observations are connected with professional knowledge with respect to one or more criterion domain(s).

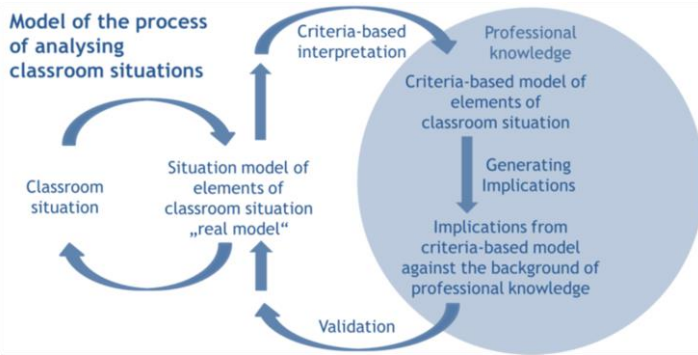


Figure 1. Noticing in the classroom situation analysis cycle (Kuntze & Friesen, 2018, p. 277)

Against the background of this model, it is plausible that in multi-criterion noticing (Kuntze et al., 2021) different noticing criteria can be expected to be in a competing relationship with each other. This means, for instance, that not only a lack of professional knowledge can be the reason for an absence of knowledge-based reasoning with respect to a criterion, but also the situation analysis with respect to a different noticing criterion (or several criteria) could dominate, so that a teacher might not consider a criterion in the noticing process, even if s/he possesses the necessary professional knowledge for a corresponding situation analysis. In such cases, analysis cycles as shown in the model could be abandoned or impeded in taking place. Multi-criterion noticing can hence be expected to be a complex process with potentially high cognitive load, due to the different criterion foci to be taken into account. Despite its relevance for classroom practice, specific empirical research is still relatively scarce. In a first study (Kuntze et al., 2021), a group of pre-service mathematics teachers were asked to analyse a vignette showing a fictitious classroom situation in a secondary school. A majority of the pre-service teachers referred to none (around 25%), one, or only up to two criteria (both less than 40%) out of the four criteria corresponding to the built-in criterion-based noticing requirements. The situation was framed as a classroom situation with students with heterogeneous learning needs, a setting in which different noticing criteria play a particularly important role (Kuntze et al., 2021). Among these, the following aspects can be crucial:

- When introducing tasks, unnecessary obstacles in language and context descriptions should be avoided in order to prevent from potential comprehension difficulties.
- The task context should be consistent with the mathematical content the teacher aims to refer to in subsequent modelling.
- Mistakes that appear in the classroom interaction should be used as opportunities for initiating learning processes in the learning group (e.g. Oser, 2005)
- Students should be encouraged to produce multiple solution pathways, and the students should not be limited to using only one solution pathway.

- Unnecessary changes of representations (Duval, 2006) without connecting the newly introduced representation with the prior representation in which a learner's difficulty has occurred can impede the learner's understanding and should therefore be avoided.
- The use of hands-on material can only be expected to support a learner's understanding if it is consistent mathematically with the question under examination and if the material use can bring an added value or insight.

These criteria with different professional knowledge foci show the relevance of the multi-criterion approach to noticing.

3. Aims of the Study and Research Questions

As mentioned above, the topic of multi-criterion noticing needs a broader empirical research base – in particular, there is to our knowledge neither any study with a focus on classroom situations in primary schools nor any study that bases its empirical results on a set of different vignettes with a parallel design. Therefore, this study aims at responding to this research need and (1) exploring whether pre-service teachers are able to successfully analyse classroom situation vignettes showing situations in primary schools with respect to several built-in criteria. Moreover, the study aims at exploring potential reasons for or patterns of difficulties in the pre-service teachers' multi-criterion noticing through a bottom-up interpretive analysis (2). More specifically, the following research questions are in the centre of this study:

- (1) To what extent are the pre-service teachers able to successfully analyse classroom situations with respect to multiple relevant analysis criteria?
- (2) Which potential patterns of difficulties in multi-criterion noticing can be detected?

4. Design and Methods

N=32 pre-service mathematics teachers (around two thirds female) were asked to analyse the vignettes. The pre-service teachers were enrolled in the master's degree program and prepared for teaching in primary schools ($N_1=14$), secondary schools ($N_2=16$), and schools for students with special needs ($N_3=2$). On average, the pre-service teachers were in their 8.8th semester ($SD=1.96$) of their studies at a University of Education in South-Western Germany.

A vignette-based questionnaire was used to collect pre-service teachers' analyses; it comprised of 8 vignettes. Vignette 2 (which is represented in Figure 2), for instance, shows a classroom situation in which the students worked on a task on speed control. The vignette is characterised by six different built-in noticing requirements, which were related to varying criteria (see those introduced above), i.e. the criteria focused on different theory elements in mathematics education. In the vignette (see Figure 2), the vignette teacher ...

- ... introduces a task with unnecessary language-related obstacles , e.g. unnecessary notions that can be expected to be unknown to some of the students (criterion 1)
- ... produces a contradiction between the multiplicative mathematical model and the task context, which can be expected to be marked by statistical variation (criterion 2).
- ... does not react or encourage other students to react to or learn from a mistake that appears in the classroom situation (criterion 3)
- ... does not acknowledge or accept other solution pathways than the one favoured by the teacher (criterion 4)
- ... changes representation unnecessarily (cubes) without connecting the previous representation with the newly introduced alternative representation (criterion 5)
- ... uses hands-on material with a student without any substantial supportive potential for the student's understanding and is mathematically not in line with the questions raised by the student previously (criterion 6).

The pre-service teachers were asked to analyse what they saw as positive/negative in the classroom situation, whether they would act similarly or which aspects they would change, and to justify their answer. The answers were coded in a top-down interpretive coding process based on the criteria introduced above (Mayring, 2015). A second rating was carried out, which yielded an acceptable inter-rater reliability of $\kappa=.70$ (Cohen's Kappa). In all cases of different ratings among the raters, an agreement could be reached in post-hoc discussions.

5. Results

The first research question focuses on the extent to which the pre-service teachers are able to successfully analyse classroom situations with respect to the multiple built-in analysis criteria. Figure 3 shows the relative frequencies of the number of criteria the pre-service teachers referred to in their noticing, i.e. in their situation analysis. In more than a quarter of the pre-service teachers' answers, none of the criteria was referred to by the participants. More than 45% of the pre-service teachers used one criterion in their situation analysis. The relative frequencies of the use of multiple criteria were lower: two, three, or four criteria were detectable in the answers of about a quarter of the participants in total in their analyses. None of the participants in the sample showed evidence of multi-criterion noticing based on five or six of the criteria introduced above.

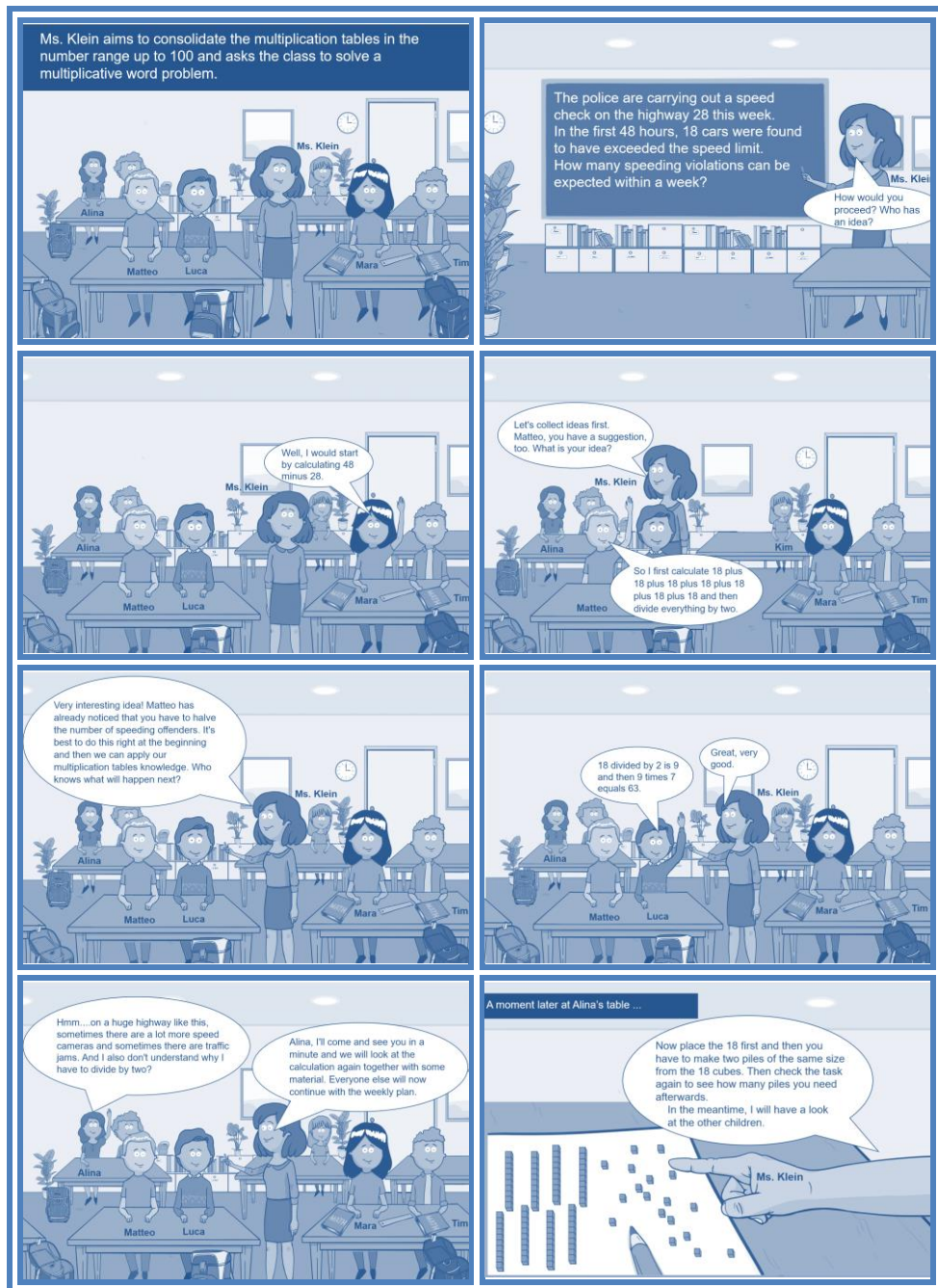


Figure 2. Sample vignette, generated with support from the coReflect@maths project (www.coreflect.eu)

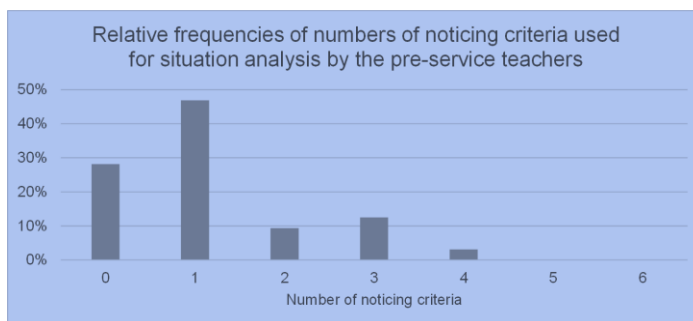


Figure 3. Number of analysis criteria in pre-service teachers' answers related to the vignette in Figure 2

The second research question focuses on possible patterns of pre-service teachers' difficulties related to multi-criterion noticing. The corresponding interpretive bottom-up analysis yielded two main observations: The first observation is the almost absent analysis of the task quality and its enactment, i.e. this part of the vignette teacher's action appears to be somewhat neglected in the pre-service teachers' analyses. The second observation is the mostly positive evaluation that several students contribute to the situation on a surface level of interaction, which appears to block the analysis of the content quality of interaction with respect to how mistakes are dealt with, of the vignette teacher's fixation on a standard solution pathway, and further content-related issues of the interaction represented in the vignette.

6. Discussion, Conclusions, and Outlook

The findings replicate the earlier evidence of pre-service teachers' difficulties in multi-criterion noticing (Kuntze et al., 2021) and extend these to the field of mathematics education in the primary school context. Profession-related learning opportunities are hence needed in mathematics teacher education in order to support pre-service teachers' development of classroom-related noticing. Research on such developments and on in-service teachers' multi-criterion noticing merits increased attention, correspondingly. The further development of vignettes for research and interventions can build on the results of the coReflect@maths project (www.coreflect.eu).

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