Pre-service teachers' views and their multi-criterion noticing: a vignette-based study

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Abstract: Mathematics teachers' noticing is a key part of their professional competence. The complexity of the mathematics classroom often requires noticing with respect of multiple analysis criteria. Such multi-criterion noticing can be expected to depend on teachers' views, as views might mediate teachers' awareness of criteria and, consequently, their noticing related to these criteria. Despite its high relevance for classroom practice and instruction-related decision-making, research into the role of such views for multi-criterion noticing is scarce. This study consequently explores such interdependencies by a reanalysis of a data set from a study with 32 pre-service teachers who had been asked to analyse classroom cartoon vignettes. In order to elicit multi-criterion noticing, these vignettes had been designed to contain noticing needs related to different criteria. The pre-service teachers' answers were coded according to whether evidence of criteria-related noticing could be found. In order to explore interdependencies with teachers' views, an additional interpretive analysis was carried out, which yielded codes for evidence of teachers' instruction-related views. The findings suggest that teachers' prescriptive views on what should happen in the mathematics classroom often led to relatively superficial positive evaluations of situation aspects and blocked a deepened knowledge-based analysis of these situation aspects. The findings call for the design of learning opportunities which address and challenge such prescriptive views in order to foster mathematics teachers' development in multi-criterion noticing. Vignette-based opportunities of profession-related learning can provide a pathway towards this goal.

Keywords: teachers' views, multi-criterion noticing, pre-service mathematics teachers, vignette-based study, teacher education.

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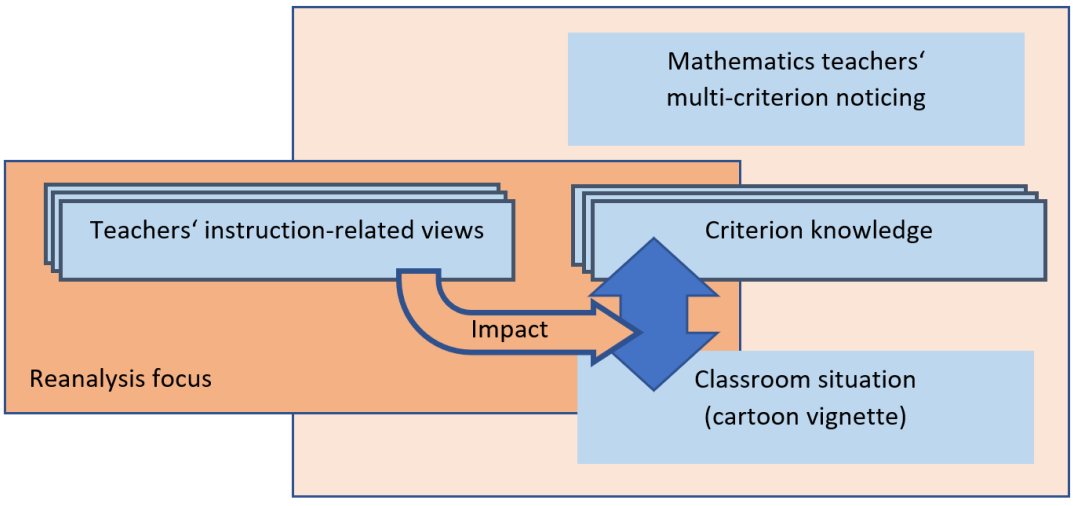


1 Introduction

Video studies (e.g., OECD, 2020; NCES, 2003) have revealed the existence of classroom instruction-related scripts, which correspond to classroom routines that can frequently be observed. Such scripts can be expected to have a backing in teachers' views on what should happen in mathematics classrooms. If teachers are asked to analyse classroom situations, these views may play a prescriptive role in teachers' situation interpretation – so they are likely to interdepend with teachers' noticing (e.g., Sherin et al., 2011, Amador et al., 2021; Choy & Dindyal, 2020; Berliner, 1991). A key part of mathematics teachers' noticing is their knowledge-based reasoning (Sherin et al., 2011) on aspects of a classroom situation: Teachers draw on specific criterion knowledge when they analyse aspects of a classroom situation, but whether and how they use such criteria from their professional knowledge might depend on their instruction-related views.

This may get particularly salient in the case of classroom situations which require drawing on several different analysis criteria, i.e., when so-called **multi-criterion noticing** (Kuntze et al., 2021) is needed. Prescriptive views on what should happen in mathematics classrooms could deviate or even block the knowledge-based analysis in the sense that not all criteria are being drawn on or that the analysis stays superficial with respect to a particular criterion. However, empirical research into the role of teachers' views for multi-criterion noticing is scarce. Consequently, based on a reanalysis of a data set with pre-service teachers, this study focuses on exploring whether and how pre-service teachers' views may have interfered in their multi-criterion noticing.

The results indicate evidence of such views in a number of the pre-service teachers' answers. In many cases, such views appear to have led to a relatively superficial positive evaluation of a situation aspect and have blocked a deeper knowledge-based analysis.

In the following sections, we will introduce to the theoretical background of this study (2), deduce the research aim (3), inform about methods and sample (4), give insight into the results (5), which will be discussed in a concluding section (6).

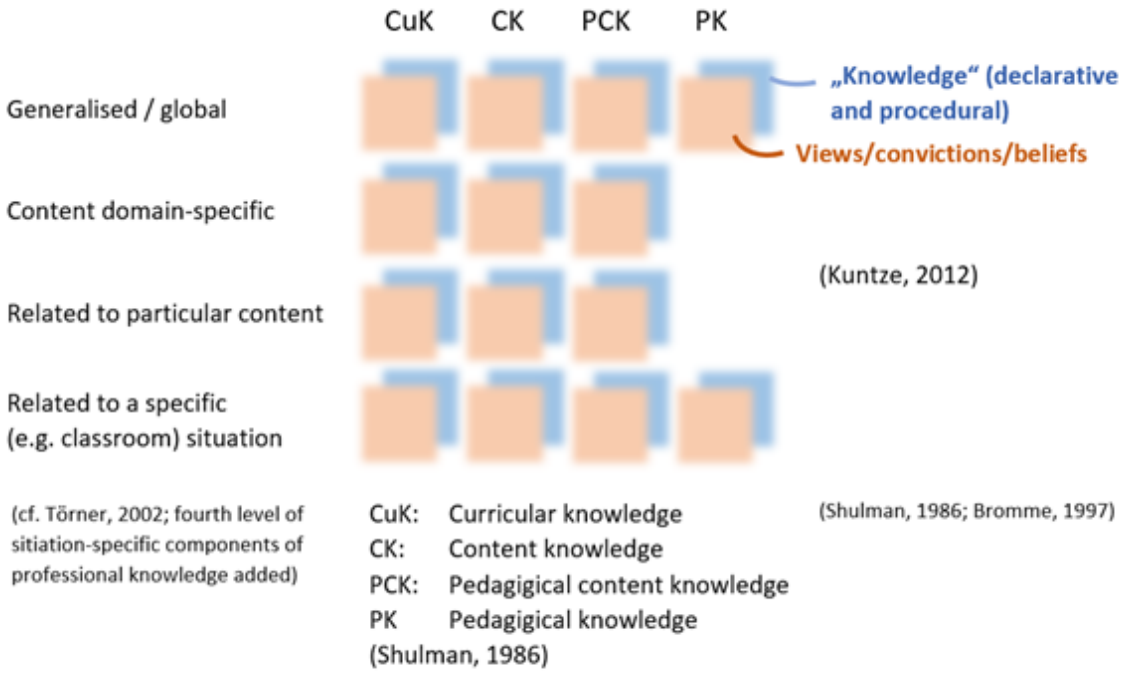
2 Theoretical background

2.1 Multi-criterion noticing

The core aspect of the notion of **multi-criterion noticing** (Kuntze et al., 2021) consists in knowledge-based reasoning (Sherin et al., 2011) related to two or several areas of criterion knowledge, on which the knowledge-based situation analysis has to draw. In general, mathematics teachers' noticing is considered to be a knowledge-based process. For an overview of components of teachers' professional knowledge, we use the model described in more detail in Kuntze (2012, see Figure 1): its three dimensions consist of (i) the well-known domains introduced by Shulman (1986, Curricular knowledge (CuK), Content knowledge (CK), Pedagogical content knowledge (PCK), and Pedagogical knowledge (PK), see vertical columns in Fig. 1), (ii) the spectrum (Pajares, 1992) between (declarative and procedural) knowledge (rear layer of the model in Fig. 1) and teachers' prescriptive views, convictions and beliefs (front layer of the model in Fig. 1), and (iii) the globality/situatedness-dimension, from global components of professional knowledge to content- and situation-specific components (inspired by Törner, 2002). Consequently, teachers' views can be rather global and independent of instructional situations (e.g., a teacher's constructivist vs. direct-transmission view of teaching and learning, Staub & Stern, 2002), or specific for a particular situation (e.g., a teacher's view that in a specific situation at the beginning of a lesson, it is best to collect the students' ideas and to select intended aspects from these for proceeding with the lesson topic). When teachers have to analyse classroom situations, the situation-related aspects of their professional knowledge can be expected to play an important role, even if professional knowledge from all levels of globality/situatedness can appear in teachers' analysis, as shown empirically in Dreher and Kuntze (2015). As far as such views are concerned, a prior study on noticing related to a single criterion (Kuntze & Friesen, 2018) revealed that general views of mathematics teachers interdepended with the quality of their classroom situation analysis.

In the case of multi-criterion noticing, drawing on professional knowledge is particularly complex, as multiple components of professional knowledge have to be connected to observations from the classroom situation. Moreover, the different knowledge-based noticing criteria can be seen as in a competing relationship with each other and as a result, keeping the focus on multiple criteria is likely to bring high cognitive load (Sweller, 1994) in the noticing process.

Figure 1. Overview model of components of professional knowledge (Kuntze, 2012)



Note. This model (Kuntze, 2012) is inspired by the levels of globality/situatedness by Törner (2002) and encompasses the spectrum between knowledge and views/convictions/beliefs (Pajares, 1992), for the domains of professional knowledge by Shulman (1986).

Against this background, the multi-criterion noticing process can be expected to be particularly fragile as far as the potential impact of teachers' views is concerned. If there are multiple demands for analysis, a teacher might focus on those which appear as particularly meaningful according to the teacher's views. Other aspects which might challenge or not be in line with the teacher's views might then be rather neglected in the analysis. Consequently, the role of instruction-related views for multi-criterion noticing merits attention and exploration in corresponding empirical research.

By teachers' views, we understand any elements of their professional knowledge which corresponds to a conviction, in particular prescriptive convictions (Bromme, 1997), acknowledging that a theoretical distinction between knowledge and views is not possible (Pajares, 1992). In line with the aim of this study, teachers' situation-related views, especially in the PCK and PK domains (cf. Fig. 1) are expected to play a role for teachers' multi-criterion noticing, even if more general views can have an impact as well (e.g., Dreher & Kuntze, 2015).

2.2 Instruction-related views – from global to situation-specific

There is a considerable amount of empirical research on rather global views of mathematics teachers (e.g., Staub & Stern, 2002; Törner, 2002; Lloyd, 2024). However, such rather global views are relatively distant from particular classroom situations. Moreover, teachers tend to organise significant elements of their professional knowledge in an episodic structure (Leinhard & Greeno, 1986), so that classroom situations can play a structuring role for professional knowledge elements. This may also contribute to explain teachers' routine-like classroom practices, such as they have often been observed and documented in video studies (e.g., OECD, 2020; NCES, 2003). Positive views of, e. g., specific classroom practices might lead teachers away from a deeper classroom situation analysis: if a feature of a classroom situation is globally seen as positive, further detail aspects of this situation element may not be analysed or analysed with less care. However, even if such considerations may appear as plausible, empirical research into these phenomena related to multi-criterion noticing is scarce, despite the high interest, given the expectable relevance for classroom practice and teacher education.

Approaches to teacher noticing have also been made through eye-tracking methods (e.g., Keskin et al., 2024). These approaches are mostly based on the assumption that teachers gaze foci reveal what they notice. Corresponding findings give insight into classroom situation features teachers centre their attention on and also that they may focus on different situation characteristics when confronted with representations of classroom situations. In the terminology of Sherin et al. (2011), this may correspond to insights into the **attending to classroom events** aspect of teacher noticing. The key noticing element of mathematics teachers' **knowledge-based reasoning** (e.g., Sherin et al., 2011) however is hardly directly accessible through such methods. Inferring from eye-tracking evidence to knowledge-based multi-criterion noticing and its possible interplay with teachers' views, in particular, is very difficult, as even the same classroom situation aspect can be interpreted by teachers against different criterion knowledge. Consequently, the conclusions teachers draw from classroom situation aspects as a result of their knowledge-based analysis can be expected to be relatively distant from where they gaze in a representation of a classroom situation and on what they focus their eyes on.

Both studies into mathematics teachers' instruction-related views and into teacher noticing often use classroom vignettes (Skilling & Stylianides, 2020). Such vignettes are representations of practice (Buchbinder & Kuntze, 2018) and show

teaching/learning situations, which bear in themselves profession-related requirements for mathematics teachers' knowledge-based analysis. Classroom vignettes can be selected from e.g., video data (mostly against the background of theory-based criteria), or they can be designed purposefully so as to contain specific analysis requirements or to be in line with specific profession-related learning goals (Skilling & Stylianides, 2020; Buchbinder & Kuntze, 2018). Correspondingly, vignettes can be seen as not only representing practice contexts, but also mathematics education theory (e.g., Kuntze et al., 2022). As far as research into multi-criterion noticing is concerned, purposefully designed vignettes in cartoon format have the advantage – among others – that analysis requirements with respect to different knowledge-based criteria can be implemented in relatively controlled ways. Moreover, teachers' views can be examined in how they may influence teachers' knowledge-based classroom situation analysis, hence in a relatively situation-specific way.

3 Research aim

As already outlined above, there is a research need related to the potential impact of teachers' views on teachers' multi-criterion noticing. This study, consequently, explores whether evidence of teachers' views in their situation analyses can be found and whether these views interfere with their multi-criterion noticing. Specifically, the following research questions are in the foreground:

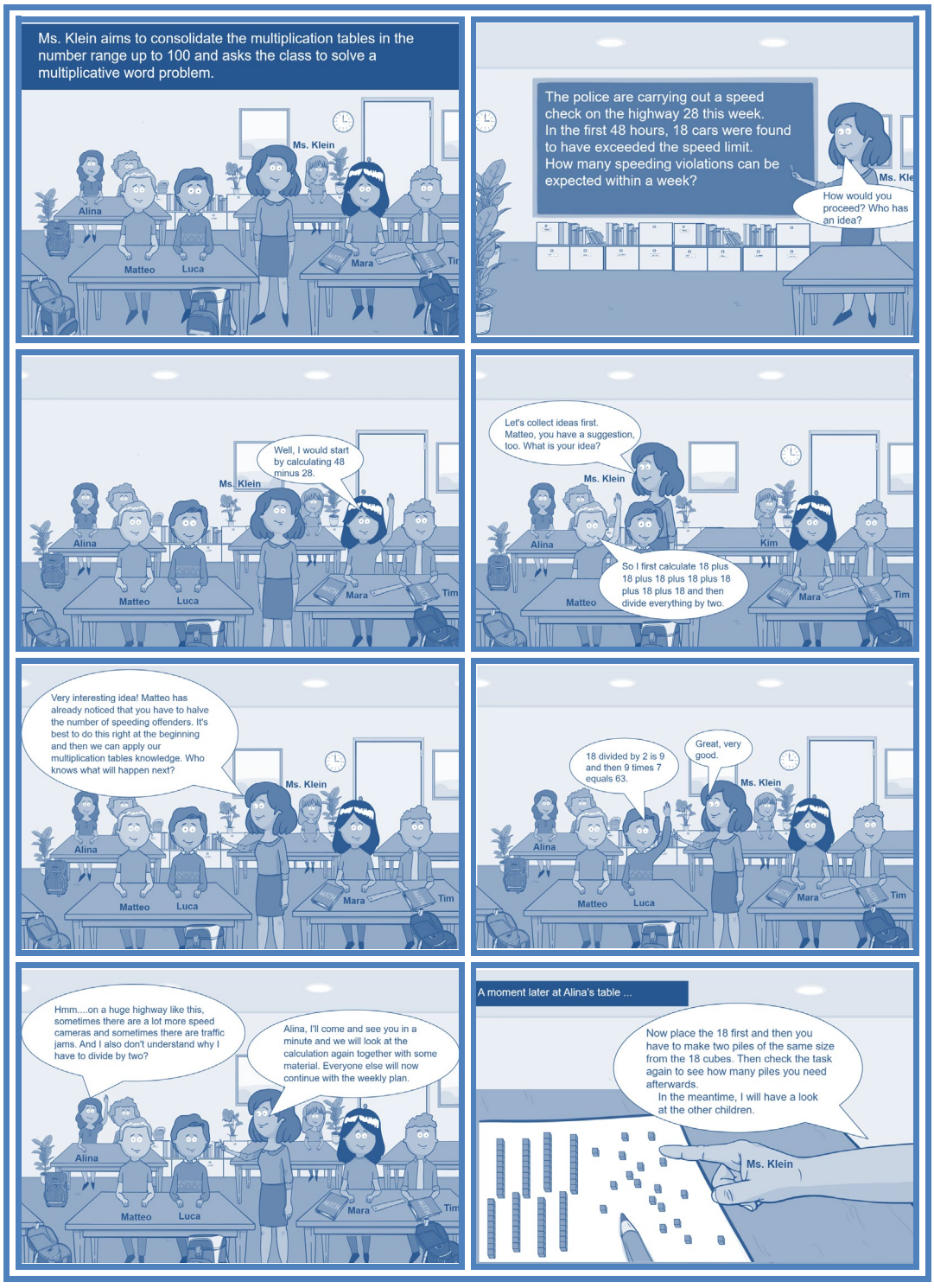
1. Is there evidence of instruction-related views of the pre-service teachers in their answers to vignette-based multi-criterion noticing tasks?
2. How do such views (in case of evidence for them) interfere in the pre-service teachers' multi-criterion noticing?

4 Methods and Sample

The sample of this study consists of a group of N=32 pre-service mathematics teachers (PST). The participants (around two thirds female) were asked to analyse several cartoon vignettes representing classroom situations, including the vignette shown in Figure 2. The PST were in their 8.8th university semester (SD=1.96) at a German University of Education; they were at the level of their master's degree's studies and prepared for teaching in primary schools (N1=14), secondary schools (N2=16), and

schools for students with special needs (N3=2). According to the structure of the local mathematics teacher education system, they had followed introductory lectures on standard topics in mathematics education in their earlier university studies. The

Figure 2. Cartoon vignette (Kuntze et al., accepted) the present reanalysis is based on



Note. This vignette has been created with support from the coReflect@maths project (www.coreflect.eu, use of graphical elements, which are also used in the digital DIVER tool for representing classroom situations in cartoon vignette format).

data was collected in the framework of a seminar, but without connection to the seminar's learning goals and by an external researcher. The mathematics educator of the seminar did not know about the details of the research instrument beforehand. The PSTs' analyses were collected with a vignette-based paper-and-pencil questionnaire with open format questions, in order to keep the data-gathering in standardised conditions and to allow the participants to sketch and draw easily, if needed. Vignette 2 (see Figure 2), which is in the foreground for this paper's reanalysis, presents a mathematics classroom in which the students worked on a task on speed control. The vignette is marked by six different built-in noticing requirements, which are related to varying criteria (see Kuntze et al., accepted, for more detail), and which focused on distinct theory elements in mathematics education.

More specifically, in the vignette (see Fig. 2), the vignette teacher …

- … uses 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 without mathematical consistency with the questions raised by the student previously (criterion 6).

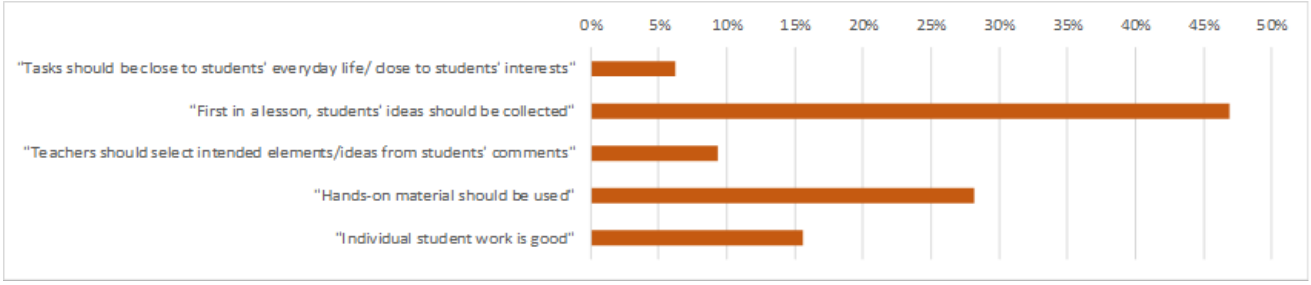
The PST were asked to analyse what they saw as positive/negative in the classroom situation, whether they would act similarly or which aspects they would change, together with justifications of their answer. The coding of the PSTs' criterion-related analyses was done according to a top-down interpretive approach, based on the criteria introduced above (Mayring, 2015). An independent second rating for the analysis codes had been carried out, which yielded an acceptable inter-rater reliability of κ=.70 (Cohen's Kappa). In all cases of different ratings among the raters, an agreement could be reached in post-hoc discussions.

Further, and addressing the specific research aims of the current reanalysis, an interpretive bottom-up analysis was added, in which evidence of PSTs' views in their answers were explored and coded. Emerging categories were listed, and in a second round of coding, the categories and codes were validated against the initial data. This methodological approach centred in the PSTs' answers to the vignettes was chosen for this reanalysis to cast light specifically on situation-related views. Moreover, potential alternative possibilities of finding out about PSTs' views (e. g., through direct questions) might have lead to biases e.g., related to social desirability. So even if not all thinkable PSTs' views can be expected to be detected through this approach, the possible interplay with the PSTs' knowledge-based situation analysis can be foregrounded through this design feature of the study.

5 Results

The first research question focuses on whether evidence of instruction-related views of PSTs can be found in their answers to multi-criterion noticing tasks. The frequencies of codes resulting from the analysis are shown in Figure 3.

Figure 3. Relative frequencies of codes related to evidence for PSTs' views



Note: The interpretive analysis of the PSTs' answers yielded five domains describing evidence related to PSTs' instruction-related views; the Figure shows the relative frequencies of the codes (N_{total}=32 PST)

Sample PST answers will be presented below, together with the results related to the second research question.

In particular, PST views related to the domains "First in a lesson, students' ideas should be collected" and "Hands-on material should be used" showed frequencies above 25%. These views are related to preferences of what should happen in mathematics lessons, however they should primarily be considered as situation-specific, as they were bound to a specific vignette situation, by research design.

The second research question concentrates on whether and how such views (in case of evidence for them) interfere in the pre-service teachers' multi-criterion noticing. In order to give insight into the data and to exemplify the coding, we present four example cases in the following. PST#8 commented:

> "Negative: The answer by Mara is ignored. The teacher should however ask, how Mara arrived at her solution and talk about it with the class, the claim 'you have to divide by 2' is left without context. This claim and the two solution pathways by Matteo and Luca should be talked through as far as their strategy is concerned, the representation of bars of tens and cubes of ones is explained without context/connection with the word problem, there is no collection of [learning] results, Positive/Negative: there is a connection to everyday life, but it is not talked through with the children (comment by Alina is not discussed)" [PST#8, translated]

In an enumeration-like style, PST#8 sums up observations in the vignette. As far as PST#8's criterion-based noticing with respect of the built-in analysis needs is concerned, it can be observed that PST#8 noticed that Mara's mistake was not used as a learning opportunity by the vignette teacher (criterion 3, "The answer by Mara is ignored. The teacher should however […]"), and that the representation of "bars of tens and cubes of ones" lacks connection with the previously used representation (criterion 5). With respect to the views domains identified in the study, the utterance "Positive/Negative: there is a connection to everyday life, but […]" was coded to indicate the PST's view that tasks should be connected to everyday life, as "but" expresses a contrast, as if the view had to be somehow overcome in order to bring up the follow-up critical remark. In this case, the analysis did not yield evidence that the PST's view had an impact on the PST's noticing, as far as the noticing criteria introduced above are concerned.

The answer of PST#18 (see below) was coded to indicate the view "Hands-on material should be used" – the corresponding utterance is combined here with an interpretation of the intention associated with hands-on material use to "visualise and clarify the context situation and the calculation process". It is unclear whether this expressed intention is really linked with the classroom situation or rather general. In any case, the hands-on material in the vignette clearly does not visualise the context situation and also the support for the calculation process is very questionable. There is no critique with respect of the material use, so that we do not have evidence of successful noticing with respect of the non-supportive use of the material (criterion 6). In this case, a potentially non-situation specific view may have blocked a deeper analysis of how the material has been used in the vignette. Moreover, the code for the

view “first in a lesson, students' ideas should be collected”, was assigned to PST#18’s answer, as the corresponding positive statement is not accompanied by specific observations from the vignette.

> “Positive is the use of [hands-on] material, which should visualise and clarify the context situation and the calculation process. Also, several solution pathways are collected, Negative: [Teacher] could have said that traffic jams … do not play a role in the calculation” [PST#18, translated]

The view “first in a lesson, students' ideas should be collected” also appears e. g. in PST#21’s answer, together with a self-identification with the vignette teacher’s approach:

> “It is good that the teacher collects the ideas, I would do this as well. […]” [PST#21, translated]

Also in this answer, there is no evidence of criterion-based noticing with respect of criterion 3 (no reaction to Mara’s mistake in the vignette). In PST#30’s answer (below), there is even an explicit positive evaluation of not reacting to Mara’s mistake together with the view that students’ ideas should be collected. The analysis of possible mistake-related learning opportunities is consequently impeded by the PST’s view.

> “I see it as positive, that the teacher connects with the suggestions of the students, at least at the beginning. Good is also the answer to Mara’s wrong answer: ‘Let’s first collect [ideas].’ […]” [PST#30, translated]

The examples give insight not only into evidence of PSTs’ views, but also into potential interdependencies with (the absence of) criterion-related noticing. Table 1 gives an overview on the full sample related to such interdependencies.

Table 1. Frequencies of code combinations

Code combinations **Views (↓) / analysis (→)**		Criterion-based analysis with respect of "mistake use as learning opportunity" (criterion 3)		
		no	yes	Sum
Evidence for view "first in a lesson, students' ideas should be collected"	no	**11**	**6**	17
	yes	**14**	**1**	15
	sum	25	7	32

Code combinations **Views (↓) / analysis (→)**		Criterion-based analysis with respect of "use of hands-on material not in line with the questions raised by the student previously" (criterion 6)		
		no	yes	Sum
Evidence for view "hands-on material should be used"	no	**17**	**6**	23
	yes	**9**	**0**	9
	sum	26	6	32

Note. The cross tables highlight that evidence of PSTs' potentially relevant views hardly coincided with corresponding criterion-related noticing.

The data in Table 1 show that evidence of potentially relevant PST's views hardly coincided with successful criterion-related noticing for the respective criteria, focusing on the views codes with frequencies above 25%, as an exploration of interdependencies with multi-criterion noticing focused on frequencies is facilitated for these codes. For example, if in a PST's answer there was evidence of one of the views, then it was a rare exception that this PST showed successful noticing with respect of the respective criterion.

6 Discussion, conclusions, and outlook

We would first like to remind of the limitations of this explorative study: The study is not representative, and the interpretive analysis of PSTs' views was limited to the data of their answers to the vignette reflection tasks in the questionnaire.

However, the research questions could be answered: As far as the first research question on evidence of instruction-related views of the pre-service teachers is concerned, the results suggest that situation-related views in PCK with a backing in more general views (Kuntze, 2012; cf. Fig. 1) were found to be most frequent: views such as "the use of hangs-on material is positive for students' learning" and "teachers should at first collect in a lesson collect students' ideas" are connected to specific types

of situations in the mathematics classroom – and at the same time, they also have a situation-overarching component, as these views appear to have been valid for some PSTs even regardless of the specific situation aspects (as those given in the vignette, e.g. aspects related to the mathematical content). As stated in Kuntze (2012), the cells in Figure 1 are not meant as strictly separate, so that the model can provide orientation for the analysis of mathematics teachers' views. The views detected in the analysis (Fig. 3) moreover can be seen as close to the teaching script in Germany (e. g. OECD, 2020), in combination with social desirability related to preferred features of mathematics teaching.

As far as the second research question is concerned, the evidence of PST's instruction-related views are mostly connected with absent criterion-related analysis with respect to corresponding criteria. We conclude that a predominance of views related to what should happen in the mathematics classroom could thus play an inhibiting role for PSTs' in-depth analysis of student thinking and learning opportunities, and hence for multi-criterion noticing. Beyond the expectable high cognitive load (Sweller, 1994), the results of this reanalysis open up a second explanatory aspect why PSTs encounter difficulties in multi-criterion noticing, as revealed in earlier studies (Kuntze et al., 2021; Kuntze et al., accepted). PSTs' views may hinder them in drawing on specific criterion knowledge when analysing classroom situations and in entering the cognitively demanding process of simultaneously focusing on several analysis criteria.

For future research into mathematics teachers' noticing (cf. e. g. Amador et al., 2021; Choy & Dindyal, 2020), this points to the need to deepen our understanding of possible inhibiting factors for teachers' noticing, and in particular for their knowledge-based analysis of classroom situations. Beyond the possible lack of professional knowledge, e.g. in the CK or PSK domains (Shulman, 1986; Kuntze, 2012) and cognitive load (Sweller, 1994), teachers' views can be expected to play a key role: they might trigger teachers' use of specific professional knowledge when connecting observations from classroom situations with analysis criteria, and they may also contribute to support a teacher's persistence to make sense of a classroom situation with respect of specific criteria even if this is cognitively demanding.

Further, research into profession-related learning with respect of multi-criterion noticing in needed. A first study has shown that multi-criterion noticing can be fostered (Kuntze et al., 2021), however without simultaneously focusing on potential developments in the PSTs' views. Following up on the results of the present study,

such views should be addressed explicitly in pre-service mathematics teacher education in order to challenge them and help PST to acknowledge the full complexity of classroom situations in their observation and analysis – also in the sense of multi-criterion noticing. Work with classroom situation vignettes (Skilling & Stylianides, 2020; Buchbinder & Kuntze, 2018; Kuntze et al., 2022) can make a contribution to teacher education in this context.

Research ethics

Author contributions

Sebastian Kuntze: writing of this paper, data analysis, collaboration in the conceptualisation of research instruments and methods—review and editing

Katrin Schall: data analysis, data gathering, collaboration in the conceptualisation of research instruments and methods—review and editing

Jens Krummenauer: collaboration in the conceptualisation of research instruments and methods—review and editing.

All authors have read and agreed to the published version of the manuscript.

Artificial intelligence

Artificial intelligence has not been used in the research or writing the article.

Informed consent statement

Informed consent was obtained from all research participants.

Data availability statement

Due to ongoing analyses, the data reanalysed in this study is currently not publicly available. However, the first author (corresponding author) can be contacted for any questions readers may have regarding the data.

Conflicts of Interest

The authors declare no conflicts of interest.

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