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► **To cite this version:**

Marita Friesen, Anika Dreher, Sebastian Kuntze. Pre-service teachers' growth in analysing classroom videos. CERME 9 - Ninth Congress of the European Society for Research in Mathematics Education, Charles University in Prague, Faculty of Education; ERME, Feb 2015, Prague, Czech Republic. pp.2783-2789. hal-01289606

HAL Id: hal-01289606

<https://hal.science/hal-01289606>

Submitted on 17 Mar 2016

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Pre-service teachers' growth in analysing classroom videos

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Analysing classroom situations belongs to the everyday requirements of mathematics teachers. From the perspective of professional development, empirical evidence related to the growth of this aspect of teacher expertise however is still scarce. Consequently, this study focuses on developments in the way pre-service teachers analyse classroom situations. In a first approach, we concentrated on pre-service teachers' analysis of how representations are dealt with in the classroom, which is a key for fostering students' understanding. The study examined whether it is possible to develop the pre-service teachers' analysis through a specific university course. The results suggest that the quality of the participants' analyses increased significantly according to several relevant criteria.

Keywords: Teacher education, video analysis, noticing, representations.

INTRODUCTION

What expert teachers should “see” in classroom situations does not only consist of noticing in the sense of identifying and describing relevant events in classroom interaction, but it also encompasses linking their observations to criteria, giving arguments and discussing the interaction against this background. As several studies have shown, differences in noticing between samples of expert and novice teachers (van Es & Sherin, 2011), it is widely accepted in the scientific community that a development in this aspect of expertise takes place over a long-term process of professional development. However, the base of empirical evidence whether pre-service teachers' analysis can be developed, in the framework of a one-semester university course, still needs to be broadened.

This study aims to respond to this research need by focusing on pre-service teachers' analyses of how

representations are dealt with by students and their teachers in classroom videos. What we understand by *growth in analysing* is the pre-service teachers' development in analysing the use of representations in classroom videos and their use of theory as fostered by a university course. We build on prior work related to research methods (e.g., Dreher & Kuntze, 2013) and examine whether it is possible to develop the pre-service teachers' analysis through a specific one-semester university course (Dreher & Kuntze, 2012). To our knowledge, this is the first study that combines quantitative and qualitative methods in order to describe pre-teachers' growth in this specific context.

We will, in the following, introduce the theoretical background of this study (1), derive the research interest of this study (2), inform about the sample and methods (3), present results (4) and discuss their implications for theoretical and practical contexts (5).

THEORETICAL BACKGROUND

There is a broad consensus that expert mathematics teachers should be able to foster learners by providing them with challenging learning opportunities and help according to their needs. Both of these requirements can be considered to be closely linked to activities of analysing – in this case analysing learning opportunities and analysing the learners' thinking or potential difficulties, for instance. Such analysis makes use of professional knowledge (e.g., Shulman, 1986; Ball, Thames, & Phelps, 2008; Kuntze, 2012), for example, when referring to criteria that are necessary for the analysis. For the case of analysing classroom situations, the concepts *teacher noticing* or *professional vision* (van Es & Sherin, 2008; Sherin, Jacobs, & Philipp, 2011) describe elements of teachers' analysis of such situational contexts in the classroom. These elements are identifying relevant events for

learning mathematics, describing the events from a criteria-oriented perspective as well as reflecting about their role and about potential implications connected with the analysis of classroom situations. These aspects make it almost obvious that noticing should be considered as knowledge-based (van Es & Sherin, 2008).

In the following, we would like to give an example of such criterial knowledge – and how this knowledge may enable teachers to analyse classroom situations – namely professional knowledge related to dealing with representations of mathematical objects. Representations stand for mathematical objects (Goldin & Shteingold, 2001), and they are the only possibility to approach these abstract and ‘invisible’ mathematical objects (Duval, 2006). This highlights the importance of dealing with representations in the mathematics classroom. Connecting different representations in the learning process can enrich a learner’s concept image (Ainsworth, 2006; Lesh, Post, & Behr, 1987), however, changing between representations is often very demanding for learners and can hence also be an obstacle for the learning process (e.g., Duval, 2006; Dreher & Kuntze, 2015).

Expert teachers (cf., e.g., Kunter et al., 2013, for the notion of ‘expertise’) are expected to be able to use such criterial knowledge when analysing relevant classroom situations regarding the use of representations. For instance, whether representations are carefully connected in the classroom by explicitly emphasising how properties of a mathematical object can be seen in different representations, whether the learners are encouraged to reflect on representations, on their use and on changes between representations, or whether a learner’s difficulty is connected with the interpretation of a specific representation (Dreher & Kuntze, 2015).

This discussion is mainly in line with the teacher-noticing framework (e.g., van Es & Sherin, 2008). However, diverse conceptualisations of teacher noticing can be found in the literature (Sherin, Jacobs, & Philipp, 2011), so the full spectrum of criterion-based analysing is not always reflected in what is understood by “noticing”. Given this situation, it may be useful to include the perspective of *systematic observation* (Schwindt, 2008), in which analysing videotaped classroom situations comprises of aspects such as *describing, explaining and evaluating situations, highlighting*

(making focused and structured comments), as well as articulating critical incidents.

Bringing together these approaches under the focus of using representations in the mathematics classroom, we define “analysing” in this study to be an interaction of the following processes: 1) Identifying relevant situations concerning the use of representations, which marks the “starting point” of an analysis; 2) evaluating such situations in a critical way based on connecting relevant situations and arguments with corresponding elements of theory regarding the use of representations; and 3) presenting/articulating the results of the analysis. These processes should neither be considered to be ordered nor completely separable, as there may be jumps between processes or simultaneous and interacting processes.

In order to develop the process of analysing with the pre-service teachers as described above, we carried out a one-semester university course. The core of this course was the analysis of videotaped classroom situations and the analysis of tasks from textbooks, both focusing on the learning potential related to using multiple representations. At the beginning of the course, key elements of theory (e.g., Duval, 2006) were introduced and the pre-service teachers developed criteria based on literature about dealing with representations. Such criteria concerned, e.g., changes between different representations (treatments and conversions); possible obstacles to students’ understanding connected to representations; or the teachers’ support in using and reflecting on representations. The criteria were used in two ways. First, as a framework for analysing and evaluating videotaped classroom situations as well as textbook tasks and second as a basis to further develop the analysed material regarding the use of representations. In case of the textbook tasks, the pre-service teachers were encouraged to change and enrich the tasks concerning the use of representations. In the case of the videos they were asked to conceive improved classroom situations regarding the use of representations. The course sessions provided the opportunity to share and discuss the ideas and material that the pre-service teachers developed throughout the course.

RESEARCH QUESTIONS

For evaluating whether it is possible to develop the process of pre-service teachers' analysing, the study aims at answering the following research questions:

- How do pre-service teachers who participated in a specific university course analyse videotaped classroom situations before and after the course?
- Is there a growth in linking relevant situations with criteria related to the use of representations?
- To what extent do the pre-service teachers examine the observed classroom situations critically against the background of corresponding elements of theory before and after the course?

SAMPLE AND METHODS

In order to answer these research questions, a video-based test was developed which comprised of two videotaped classroom situations and a corresponding questionnaire with different questions (see Table 1). The test was completed by 18 pre-service teachers (14 of them female) in a pre-post test design at the beginning and the end of a four-month university course (one 90-minute-session per week). The participants were all advanced or last-year students at Ludwigsburg University of Education, preparing to teach mathematics at primary or secondary schools.

The first video clip lasted about six minutes and shows a classroom situation with individual work. A student working on a problem in her book has difficulties creating three-digit numbers where the sum of the digits would be nine. The teacher asks her to draw three columns in order to represent the hundreds, tens and units on a place-value board. He then gives her nine chips, asks her to arrange them in the three columns and to tell him the number she had arranged. As the girl appears to have problems in translating the chips

into numbers, the teacher shows her how to write down the number of chips under each column. At the end of the video, the teacher leaves the student with the instruction to arrange and write down more numbers.

The second video clip lasted about seven minutes and shows a whole-class activity where a teacher works out the solution to an age word problem with her class. First she lets the students read the problem in their book and they explain in their own words the relation between the age of a father and his son. Then she draws a table on the board to set up the variables and asks the students to label them with their definitions. At the end of the clip, the teacher tells the students to use the information from the table to set up equations and reminds them of important solution steps.

Although the two classroom videos seem to be quite different, they share important aspects concerning the use of representations that appear suitable to evoke pre-service teachers' attention and elicit analysing in this context. In both videos, the teachers use different registers of representations in order to support their students' understanding. However, both teachers miss important opportunities to offer their students help in dealing with those representations, for example, in the sense of translating between them, connecting them or reflecting on their use.

Table 1 shows the open-ended questions of the questionnaire the pre-service teachers had to answer at the beginning and the end of the university course. Item 1 aims at eliciting pre-service teachers' analysis without specifically prompting them to look at representations. Items 2 and 3 prompt the pre-service teachers to look at representations and motivate evaluations of corresponding events.

The answers to the open-ended questions were coded by two researchers, according to a top-down coding manual. The inter-researcher agreement was found to be good ($\kappa = .83$). For item 1, it was coded whether representations were mentioned, whether critical

Item 1	In what way was the students' understanding (not sufficiently) supported in the video clip? Please describe.
Item 2	Please evaluate the support given by the teacher regarding the use of representations.
Item 3	Please evaluate the support given by the teacher regarding the translation between different representations.

Table 1: Open-ended questions for each videotaped classroom situation

evaluations of the teachers' support were made, and whether there was a reference to elements of theory regarding the use of representations. Critical evaluations were defined as evaluations that also included negative judgements of the teachers' support as shown in the videos. Regarding elements of theory related to the use of representations, it was coded whether an answer was related to at least one of the following five aspects: support in using representations, translating/ changing between representations, enhancing reflections on the use of representations, clarification why certain representations were used, and how learning was fostered by the way representations were dealt with.

Before answering items 2 and 3 in which the participants were prompted to look at representations (see Table 1), the pre-service teachers were given a definition of representations in the mathematical context in which examples of different registers of representations such as symbolic or iconic were mentioned. Accordingly, it was coded whether the answers contained both a reference to the corresponding elements of theory (teachers' support in using representations or translating between representations) and critical evaluations of the teachers' support.

RESULTS

We would like to start with two sample answers, which may also illustrate the coding process (see Figures 1 and 2).

Already in the pre-test answer, the pre-service teacher in Figure 1 (see below) appeared to give critical eval-

uations, but these evaluations are not connected to representations and the way they are dealt with (e.g., "The way of problem solving has no relation to a real-world problem"). The criterion of using or dealing with representations is not referred to. However, in the post-test the pre-service teacher does not only attend to the representation registers from the video clip ("word problem", "table", "equation"), but also manages to analyse their use according to different elements of theory (e.g., "But what about the connections?"). Further, both positive and negative evaluations of corresponding events are given (e.g., "Chance unfortunately not optimally taken"), which was coded as critical evaluation.

Comparing the answers in pre-test and post-test, the analysis of this case suggests a progression in the quality of the analysis.

In the sample answer for item 2 (see Figure 2 below), the pre-service teacher's analysis of the video clip remains somewhat incomplete both in pre-test and post-test.

Although referring to the teachers' support in using representations in the pre-test as prompted by the question, there is no critical evaluation of this support. The pre-service teacher mainly sticks to mere descriptions of events (e.g., "student was asked to draw the place-value board herself; numbers were written directly under the board"). In the post-test, the pre-service teacher suggests alternatives for the teacher's action. The expressions used (e.g., "could have explained") suggest that the participant sees the video clip critically with respect to the suggest-

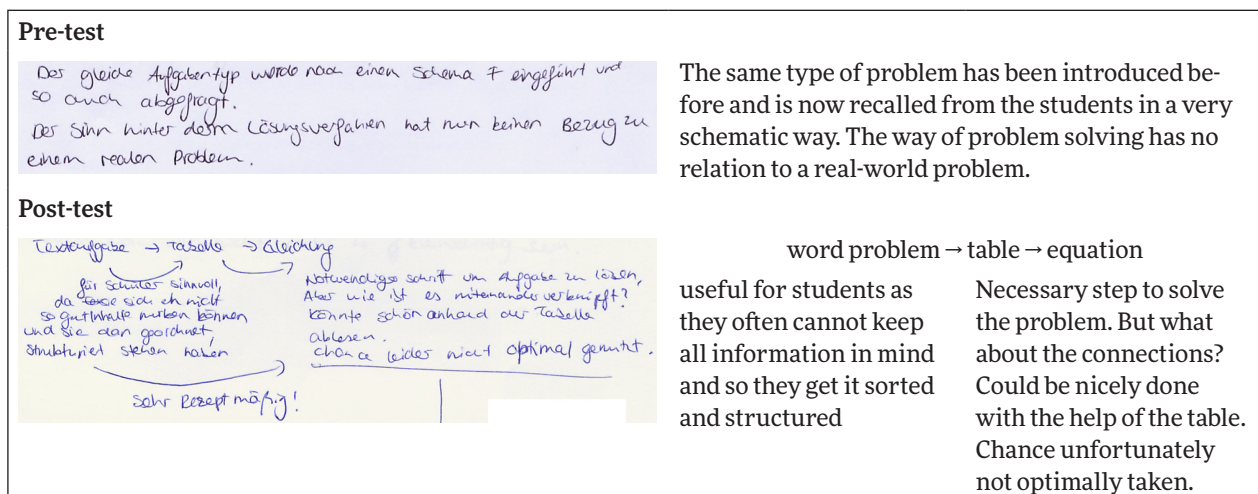


Figure 1: Sample answer and translation for item 1, video 2, questionnaire #9

<p>Pre-test</p> <ul style="list-style-type: none"> • Schülerin sollte die Tafel selbst machen und Nadel hineinlesen • Zahlen wurden direkt darunter geschrieben um den Bezug zwischen Stellenwerttafel und Zahl zu zeigen • Anregungen durch Fragen: Sollen wir das mal machen? <p>Post-test</p> <ul style="list-style-type: none"> • G hat Material eingesetzt • hat die Schülerin handeln lassen • hätte evtl. dieses Material ausführlicher behandeln & nutzen können 	<ul style="list-style-type: none"> – student was asked to draw the place-value board herself and to arrange the chips – numbers were written directly under the board to show the connections between the place value and the number – stimulating questions: Should we try to do this? <ul style="list-style-type: none"> – he brought in material – [he] let the student take action herself – [he] could have explained and used the material in more detail
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Figure 2: Sample answer and translation for item 2, video 1, questionnaire #16

ed alternatives. However, the coding yielded no clear direct reference to the criterion of using representations beyond rather general remarks (e.g., “could have explained and used the material in more detail”). In the case of these answers, we could thus not detect a progression in the quality of analysis according to our coding categories.

On the basis of the coding of answers in the pre-test and post-test, we could count how often the corresponding codes were assigned to the pre-service teachers' answers. Table 2 shows the results of all 18 pre-service teachers for the first item by displaying the relative frequencies of the codes in per cent. The

data mainly suggests an overall growth in analysing for this item. In the post-test, nearly all pre-service teachers mentioned representations when asked about the teachers' support of students' understanding in the video clips and there is also a growth in referring explicitly to the use of representations as analysis criterion.

Figure 3 shows the results for the code frequencies related to items 2 and 3. The data reveals a strong growth of the pre-service teachers' criterion-based analysing consisting both of the reference to the teachers' support in using representations or translating between them, and of the critical evaluation of corresponding

	video 1		video 2	
	pre	post	pre	post
mentioned representations	72%	94%	78%	100%
gave critical evaluations of the teachers' support	50%	67%	61%	39%
referred to the use of representations/elements of theory	50%	56%	50%	67%

Table 2: Code frequencies related to pre-service teachers' analysis in item 1

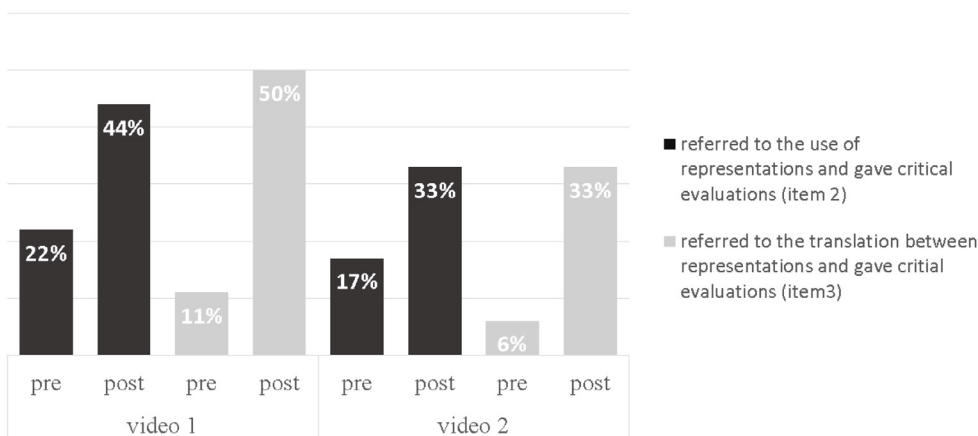


Figure 3: Code frequencies related to pre-service teachers' analysis in items 2 and 3

events in the video clips. However, even in the post-test, not more than half of the students carried out an analysis satisfying the code definition.

Concerning the pre-service teachers' connections to elements of theory, data analysis shows a growth in the number of references to *translations between representations* from pre-test to post-test (see Table 3). While the majority of the pre-service teachers mentioned only up to one translation in the pre-test, most answers contained two or even three connections to this element of theory in the post-test. Comparable to these findings, there was a growth in the number of references to additional elements of theory in the answers to items 2 and 3: nine pre-service teachers made additional connections to the elements of reflection or goal transparency in the pre-test, whereas 17 pre-service teachers additionally referred to elements such as reflection, goal transparency or the fostering of learning processes in the post-test.

In a further step in our data analysis, we made use of indicator scores, which can be seen as an exploratory first step towards quantitative forms of describing how criteria-based pre-service teachers analyse classroom situations. For this explorative quantification approach, code-based scores were created as follows.

In the case of the answers to item 1, one point was given if the answer mentioned representations. In this case, an additional point was obtained if not only the mere existence but also the *use* of representations was mentioned explicitly, and another point corresponded to the code of "critical evaluation given". Like this, the participants could reach a range from 0 up to 3 points for each video, resulting in a total score ranging from 0 up to 6 points. In the case for the answers to items 2 and 3, one point was given only if the answers contained both critical evaluations and relations to the teachers' support in using representations (item 2) or the teachers' support in translating between rep-

resentations (item 3), resulting in a total score ranging from 0 up to 4 points.

Data analysis for the score based on item 1 showed that the pre-service teachers had on average higher scores in the post-test ($M = 4.22, SE = 0.25$) than in the pre-test ($M = 3.33, SE = 0.38$). This increase is significant and corresponds to a medium-sized effect ($T = -3.06, df = 17, p < .01, r = 0.60, d = 0.55$).

For items 2 and 3, the comparison between the scores yielded comparable results: the pre-service teachers reached on average higher scores in the post-test ($M = 1.73, SE = 0.32$) than in the pre-test ($M = 0.53, SE = 0.19$). This increase is also significant and corresponds to a strong effect ($T = -3.52, df = 14, p < .01, r = 0.69, d = 1.62$).

DISCUSSION AND CONCLUSIONS

Before discussing the results in detail, we would like to recall that the data has to be interpreted with care. We do not have data from a control group so far and the sample size restricts the possibility of making any broader generalisations from the results.

However, the research questions of the study could be answered and the findings show the pre-service teachers' development in analysing classroom videos throughout the university course. Even if not all pre-service teachers have reached the level of in-depth analysis with an extensive reference to aspects of relevant theory, the overall results suggest a deeper and more careful analysis of the videotaped classroom situations after the university course. On average, more pre-service teachers referred to representations in their analyses after the course, more critical evaluations of the teachers' support in the videos were given and the pre-service teachers made more connections between the classroom situations and criterial knowledge related to the use of representations. A particular growth could be detected in the pre-service teachers'

	video 1		video 2	
	pre	post	pre	post
number of references to the translation between representations				
0	67%	22%	28%	17%
1	28%	17%	50%	11%
2	6%	28%	17%	33%
3 or more references	0%	33%	6%	39%

Table 3: Pre-service teachers' connections to theory in items 2 and 3

analysis of relevant situations where the translation between different representations played an important role, which is a key to students' understanding.

At first sight, a possible explanation of the observed growth might be the pre-service teachers' increased awareness of representations and their use in the post-test. Taking a closer look, however, this interpretation of the findings appears too simplified. Already in the pre-test, the teachers were prompted to the criterion of dealing with representations in items 2 and 3, which was not reflected in their answers. Moreover, in the post-test, many pre-service teachers still were not able to analyse the classroom situations in depth as the corresponding coding only showed frequencies of up to 50% (Figure 3), indicating that the potentially higher awareness of dealing with representations was not sufficient for carrying out successful analysis. This underpins the significance of both components of the analysing process: the identification of relevant classroom situations as well as their critical and theory-based evaluation.

The quantitative results suggest that it is possible to describe the quality of teachers' analyses by quantitative measures and thus to tap into a key aspect of their expertise in follow-up research. Corresponding instruments are currently being developed.

For practice in teacher education, the findings clearly highlight needs of professional development. The analysis of classroom situations offers challenging learning opportunities for pre-service teachers and corresponding competencies should be fostered. This study can offer a first orientation to how criterion-based analysing of classroom situations could be the subject of a focused university course (cf., Dreher & Kuntze, 2012) in which pre-service teachers showed growth in this aspect of professional expertise.

We thus conclude, that pre-service teachers' growth in analysing classroom videos can be encouraged in the framework of a university course, but that this growth should be seen as one step in a longer chain of ongoing professional development.

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