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How does the professional vocabulary change when pre-service teachers learn to analyse classroom situations?

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We conducted a university course with pre-service teachers specifically focused on learning to analyse the use of multiple representations in classroom situations. We were particularly interested in the professional vocabulary pre-service teachers used when they analysed these classroom situations. Before and after the course, we collected 136 written analyses from 17 pre-service teachers who were asked to evaluate the use of multiple representations in four classroom situations. Our findings indicate that the pre-service teachers' professional vocabulary improved with respect to breadth and specificity. They also used more terms related to essential aspects of theory on multiple representations. As teachers' increased and appropriate use of professional vocabulary appears to play a role with regard to their competence in analysing classroom situations, further research into this topic is encouraged and might give insight into corresponding competence development.

Keywords: Teacher education, analysing classroom situations, professional vocabulary.

Introduction

Being able to analyse classroom situations, that is to identify and interpret events which are relevant for students' learning, is an important prerequisite for providing students with adequate learning opportunities and learning support (e.g., Sherin, Jacobs & Philipps, 2011). Since the use of multiple representations and the ability to flexibly change between them plays an essential role for the learning of mathematics (Duval, 2006; Acevedo Nistal et al., 2009), teachers' ability to *analyse classroom situations regarding the use of representations* can be described as an important aspect of mathematics teachers' professional competence (Friesen & Kuntze, 2016; Friesen, 2017). The question of how such a competence can be developed and how competence development in that field can be assessed and described consequently merits special attention in mathematics teacher education.

The study presented in this paper connects our prior research of pre-service teachers' growth in analysing classroom videos (Friesen, Dreher & Kuntze, 2015) with teachers' use of professional vocabulary when analysing classroom situations regarding the use of representations (Friesen, Mesiti & Kuntze, 2018). Since the International Classroom Lexicon Project (e.g., Mesiti & Clarke, 2017) has drawn attention to the professional vocabulary teachers use when describing classroom phenomena, it has been assumed that what teachers identify and interpret when observing classroom situations might not only be channelled by their knowledge but also by *what they can name*. Taking also into consideration that learning the language of a discipline can be regarded as part of learning

the discipline itself (e.g., Schleppegrell, 2007), we assumed that documenting pre-service teachers' use of professional vocabulary might provide insight into their development when they learn to analyse classroom situations. In this next phase of our research, we turn our attention to change in pre-service teachers' professional language when they learn to analyse classroom situations regarding the use of multiple representations.

Below we outline our study's theoretical background, starting with multiple representations and their role for the teaching and learning of mathematics. After presenting the state of research into teachers' competence of analysing and teachers' use of professional vocabulary, we follow with a description of the university course from which we obtained our data.

The use of multiple representations in the mathematics classroom

The use of multiple representations plays a crucial role for the teaching and learning of mathematics. As mathematical objects are abstract in nature, they can only be accessed by using representations such as: formulae, graphs, diagrams, tables, written and spoken language (e.g., Goldin & Shteingold, 2001). Bruner (1966) coined three stages of representation in which any idea or body of knowledge can be presented to a learner: by action (*enactive* representation), by images or graphics (*iconic* representation) or by symbolic propositions (*symbolic* representation). According to Duval (2006), representations of mathematical objects can be organised in a more fine-grained manner in so-called representation *registers*. Each register (e.g., oral or written language, symbols, shapes, drawings, sketches, diagrams, graphs, etc.) contains some information about the mathematical object it stands for or emphasises certain aspects of the mathematical object. Since many tasks involve several representation registers and some registers are more efficient for solving problems than others, the use of *multiple registers* of representations can be regarded as indispensable for the teaching and learning of mathematics. Teachers and students generate and use multiple representation registers for introducing new topics, for explaining, for solving problems and for sharing ideas in the classroom (Duval, 2006; Acevedo Nistal et al., 2009).

Numerous studies show, however, that using multiple representations of a mathematical object and changing between them involves high cognitive demands for the learners (Ainsworth, 2006; Duval, 2006): The changes between multiple representation registers, so-called *conversions*, require the learners of mathematics to identify and coordinate the relevant constituents from different representation registers. It can consequently lead to serious problems in understanding when students fail to see that different registers (e.g., verbal explanation, written symbols and drawing) represent the same mathematical object (Duval, 2006).

For this reason, mathematics teachers have to be able to *analyse classroom situations* regarding the use of multiple representations in order to support their students in connecting different representation registers when conversions occur (Friesen & Kuntze, 2016). We define such competence of analysing as a teacher's ability "to link relevant observations in a classroom situation to corresponding criterion knowledge so that unconnected changes of representations can be identified and interpreted with respect to their role as potential learning obstacle" (Friesen, 2017, p. 39). Being able to analyse classroom situations as described above can be regarded as highly

relevant for students' learning with multiple representations and thus for the instructional quality in the mathematics classroom.

The role of professional vocabulary for analysing classroom situations

Representations of practice in the form of video clips, narratives, student-teacher dialogues or cartoons play an important role when pre-service and in-service teachers learn to analyse classroom situations (e.g., Sherin, Jacobs & Philipps, 2011). Breaking down practice into its constituent parts requires, however, a *specific language* for describing and naming these parts (Grossman et al., 2009). It is also assumed that learning the language of a discipline is a part of learning the discipline itself (Schleppegrell, 2007). There is hence a consensus that having a specific language for describing teaching practice is essential in pre-service teacher education as well as for the discussion of in-service teachers' practice and its development within the teaching community (Grossman et al., 2009). At the same time, the teaching community has been characterised as suffering from a lack of professional language (Grossmann et al., 2009) whereas different communities, speaking different languages, have been found to employ different naming systems (e.g., Mesiti, Clarke, Dobie, White & Sherin, 2017).

In this context, the International Classroom Lexicon Project (e.g., Mesiti et al., 2017) seeks to document the *professional vocabulary*, or lexicon, mathematics teachers use *when describing classroom phenomena*. Research teams in ten countries (Australia, Chile, China, the Czech Republic, Finland, France, Germany, Japan, Korea and the USA) are currently identifying and comparing the lexicon of their middle school teachers (e.g., Mesiti & Clarke, 2017). Mesiti et al. (2017) argue that teachers' interactions with classroom settings are mediated by their capacity *to name* what they see and experience. The concept of teacher noticing (e.g., Sherin, Jacobs & Philipps, 2011) plays an important role in this context; it is assumed that what teachers identify and interpret in a classroom situation is not only constrained by their knowledge and experience but also by *what they can name* (Mesiti et al., 2017). We therefore concluded, that the professional vocabulary teachers use also provides potential for research into teachers' competence of analysing the use of representations. In a corresponding study, we took an initial step and documented the professional vocabulary used by in-service teachers in their written analysis of classroom situations regarding the use of representations (Friesen, Mesiti & Kuntze, 2018). The results encouraged us to use a similar method for the documentation of pre-service teachers' professional vocabulary before and after a university course with the objective to gain insight into the participants' development when they learn to analyse classroom situations. In the following paragraphs we will describe the university course, our research questions and our method for documenting the pre-service teachers' professional vocabulary.

Learning to analyse: a university course

The objective of this single semester course is to develop pre-service teachers' competence when analysing the use of multiple representations. It is offered on a regular basis at Ludwigsburg University of Education (e.g., Friesen, Dreher & Kuntze, 2015). At the beginning of the course, key elements of theory related to the use of multiple representations in the mathematics classroom are

introduced. Accordingly, criteria are developed which are used during the course for the analysis of videotaped classroom situations and textbook learning material. The core of the course work is the collaborative and criteria-based analysis and reflection of how multiple representations are used and dealt with in learning material and classroom situations. Emphasis is put on the pre-service teachers' ability to distinguish different registers of representation and to identify unconnected conversions and interpret them with respect to their role as potential learning obstacles. In this context, the participants become acquainted with specific terms from theory on using multiple representations in the mathematics classroom, such as *register*, *conversion*, *change of representations*, *connection of representation registers*, etc. (cf. Duval, 2006). The course sessions also provide the opportunity to further develop and improve learning material and classroom situations according to the theory-based criteria. The pre-service teachers are, for example, encouraged to create alternatives for the teachers' reactions in videotaped classroom situations with the aim to support students in using multiple representations and making connections between different representation registers.

Research interest and research questions

What teachers see in classroom situations might be channeled by *what they can name* and it might consequently be assumed that teachers' professional vocabulary plays a role with respect to their degree of competence and sophistication in analyzing classroom situations. We are consequently interested in how professional vocabulary develops and how the professional vocabulary used by pre-service teachers changes during a single semester university course. Building on our prior research (Friesen, Mesiti & Kuntze, 2018), we are particularly interested in identifying changes in the professional vocabulary of pre-service teachers after having learned to analyse classroom situations regarding the use of multiple representations. This leads to the following research questions:

- What professional vocabulary do the pre-service teachers use for analysing classroom situations before and after a course focusing on the use of representations?
- In what way does the professional vocabulary change?


Sample, methods and data analysis

The data analysed in this study was collected from 17 mathematics pre-service teachers who studied the university course described above. All but one of the pre-service teachers were female, between 21 and 27 years old ($M_{age}=23.2$; $SD_{age}=1.5$) and in their sixth or seventh semester.

In order to address the research questions, we asked the pre-service teachers at the beginning and end of the university course to evaluate other teachers' teaching in four different classroom situations (learning of fractions, grade six). The classroom situations were presented in a paper-and-pencil test in the two formats text (student-teacher-dialogues complemented with pictures of the teacher-generated and student-generated representations) and comic (cf. Friesen, 2017). Each classroom situation was followed by an open-ended question: *How appropriate is the teacher's response in helping the students to solve the task? Please evaluate the use of representations and give reasons for your answer.* The narratives of the four classroom situations were designed in a

similar way: A group of students struggle with solving a task, they show the teacher their workings with a certain representation register (e.g., calculation, written symbols) and ask the teacher for help. Initially, the teacher tries to support the students with a verbal explanation. As they still do not understand, the teacher changes the representation register (e.g., by making a sketch or drawing). However, the teacher does little to connect the student-generated and the teacher-generated representations and there is no support for the students to see that the different representations belong to the same mathematical object. Based on the theory of learning with multiple representations as outlined above, such unconnected conversions are very likely to cause further problems in the students' understanding. The teacher's response can therefore be evaluated as not appropriate for helping the students in all of the four classroom situations.

As the 17 pre-service teachers were asked to analyse four classroom situations before and after the university course, 136 written answers could be examined for this study. In order to extract the professional vocabulary from the pre-service teachers' answers, we adopted a method previously developed with similar research involving in-service teachers (Friesen, Mesiti & Kuntze, 2018). We were interested in identifying change with respect to the professional vocabulary in use by pre-service teachers before and after the course, hence, the answers from the pre-test and the post-test were analysed separately. As a first step, lexical items (nouns, verbs, adjectives, adverbs carrying the meaning of the sentence) were extracted from the pre-service teachers' written answers. As classroom phenomena were also described using terms which were non-lexicalised (i.e. not expressed as a single word), we included such terms in a second step of analysis. In the next step, we grouped the extracted terms in lexical categories which we had derived in our prior study (Friesen, Mesiti & Kuntze, 2018): (1) terms related to general pedagogical practices which are not specific to the mathematics classroom, (2) terms related to mathematical content and to practice specific to the mathematics classroom and (3) terms related to representations and their use in the mathematics classroom including stages of representations, representation registers, changes of representations and the connection of registers. Figure 1 shows these steps of analysis for a pre-service teacher's answers from the pre-test and the post-test (same classroom situation).

<p>Ich finde die Erklärung am Zahlenstrahl nicht wirklich geeignet, da es auch eine formale Erklärung ist. Die erste Erklärung ($\frac{2}{3}$ geht öfter in 6 als 1) finde ich verständlicher. Das könnte ikonisch dargestellt werden, um eine anschauliche Erklärung zu geben.</p> 	<p>I think that the explanation with the number line is not really appropriate because it is also a formal explanation. I find the first explanation ($2/3$ go more often in 6 than in 1) is easier to understand. This could be represented iconically in order to give an illustrative explanation. (pre-test, written analysis for classroom situation 1)</p>
	<p>It is good that the teacher uses other representations instead of trying to explain only the calculation. I think it is not good that the teacher uses two different representations (verbal: how often $2/3$ go in 6, on the number line: arithmetic operations). She doesn't connect these representations to each other. It would be better to</p>

<p>Es ist gut, dass die Lehrperson andere Darstellungen verwendet und es nicht nur anhand der Rechnung zu erklären versucht.</p> <p>Ich finde es nicht gut, dass die Lehrperson zwei verschiedene Darstellungen nutzt (weil wie oft passt $\frac{2}{3}$ in 6, am Zahlenstrahl Rechenoperationen).</p> <p>Sie verknüpft diese Darstellungen nicht miteinander.</p> <p>Es wäre besser, nur eine zu wählen und diese genauer zu zu erklären (z.B. $\frac{2}{3}$ in 6 bildlich darstellen)</p>	<p>choose just one representation and explain this one in more detail (e.g., represent $\frac{2}{3}$ in 6 iconically).</p> <p>(post-test, written analysis for classroom situation 1)</p>
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Figure 1: Sample answers from pre-test and post-test; extracted terms are shaded

Results

The analysis of the pre-service teachers' written responses for professional vocabulary resulted in the extraction of 422 terms (pre-test) and 359 terms (post-test). Figure 2 indicates that the share of terms related to representations and their use in the mathematics classroom has increased from pre-test to post-test (from 38% to 52%).

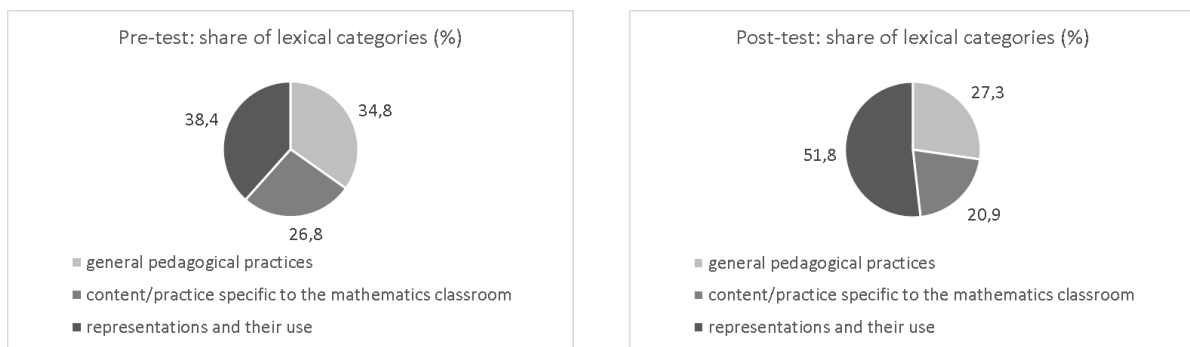


Figure 2: Extracted terms organised in lexical categories, pre-test and post-test

A closer examination of the terms that were most frequently used to describe phenomena of the presented classroom situations reveals that there was little change between pre-test and post-test concerning the lexical categories (1) general pedagogical practices and (2) mathematical content/practices. The terms that were most frequently used to describe general pedagogical practices were *(to) explain/explanation* and *(to) understand/understanding* both in the pre-test and the post-test. The terms that were most frequently used to describe content and practices specific to the mathematics classroom were *fraction*, *(to) divide*, *(to) multiply* and *result* both in the pre-test and the post-test. This is very similar to the terms most frequently used by in-service teachers when analysing the same classroom situations (see Friesen, Mesiti & Kuntze, 2018 for a list of terms). The change in the pre-service teachers' professional vocabulary from pre-test to post-test became visible in the lexical category grouping terms related to representations and their use in the mathematics classroom. First, we compared the shares of subcategories, as can be seen in Figure 3. About half of the terms related to representations were used to describe different representation registers. The share of terms used to describe stages of representations decreased from pre-test to post-test, whereas, in the post-test, more terms were used to describe classroom phenomena related

to changes of representations and the connection of registers; both essential aspects for learning with representations.

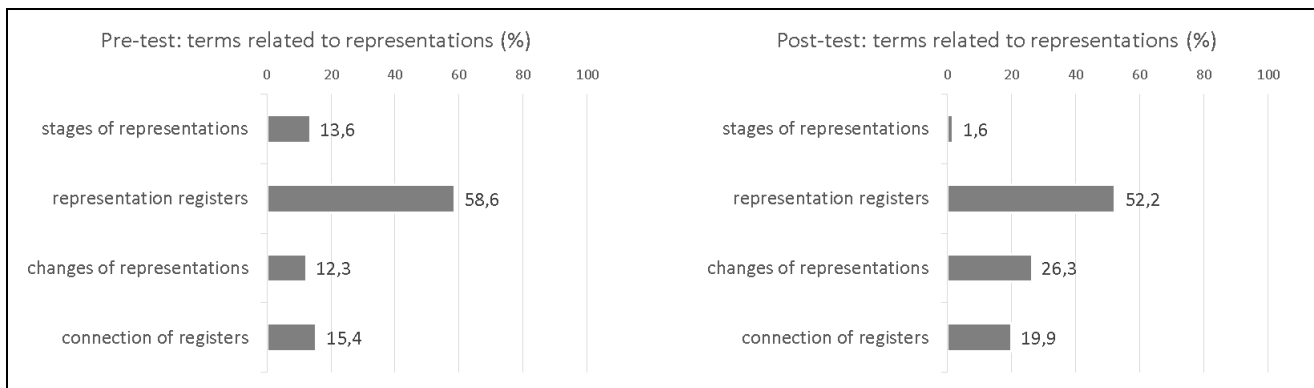


Figure 3: Terms related to representations, change in subcategories between pre-test and post-test

The terms changed, however, not only regarding their number but also regarding quality. In the case of terms used for describing registers of representations, we found for the pre-test that besides the specific terms *number line*, *diagram*, *drawing* and *pizza*, the general term *representation* was used 45 times to describe very different kinds of registers in the four classroom situations. In the post-test, the pre-service teachers used the general term *representation* only 15 times. Instead, terms with *register* appeared 15 times to describe the same phenomena (e.g., *diagram register*, *drawing register*, *verbal register* etc.) or the pre-service teachers extended the word *representation* by adding a more specific description, e.g., *representation with pizzas*, *iconic representation*, *verbal representation*, etc. In the case of terms for describing changes of representations, the pre-service teachers used terms such as *choose* or *use another representation* in the pre-test. The most frequent terms for describing changes of representation were constructions with *illustrate*, such as *illustrate the problem with pizza slices* (2 and 8 times, respectively). In the post-test, more specific terms such as *change of representations* and *conversion* could be found in the answers (6 and 12 times, respectively).

Discussion

Whereas the language used by students and teachers in the mathematics classroom plays an essential role in mathematics teacher education and corresponding research, the professional language teachers use for analysing classroom situations and describing classroom phenomena has so far garnered less attention. The argument that teachers are not likely to identify and interpret classroom phenomena that they cannot name underlines, however, the importance of supporting the development of a professional lexicon as part of teacher education programmes. The aim of this study was to document pre-service teachers' professional lexicon with a focus on representations and to examine if pre-service teachers' use of professional vocabulary changes when they learn to analyse classroom situations in a university course. Although this study is limited to a small sample and to analysing the use of representations, its findings encourage further research into this topic and further development of the applied methods. The documentation of the pre-service teachers' professional vocabulary before and after the course revealed a change concerning several aspects: First, the pre-service teachers' lexicon concerning multiple representations and their use appears to

have grown and has become more specific at the same time; additionally, the professional vocabulary used in the post-test is, for example, characterised by a wider range of terms for aspects that play a central role for learning with multiple representations (changes of representations, connection of registers) and also indicates a greater level of specificity regarding terms related to registers of representation. It might be concluded that having a name for certain registers can help to identify them whereas identifying different registers of representation can be seen as necessary prerequisite to identify conversions and to interpret them as potential learning obstacles. The relation between teachers' professional vocabulary and their corresponding competence of analysing should consequently be investigated in more depth. A next step is to bring together the documentation of teachers' professional vocabulary and their competence scores when analysing classroom situations regarding specific criteria.

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