Competence Assessment with Representations of Practice in Text, Comic and Video Format

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Abstract Representations of classroom practice are considered to be particularly suitable for assessing aspects of teacher competence. However, the role of representation formats in the design of test instruments has been investigated only scarcely so far. Consequently, the study presented in this chapter addresses the question whether N = 162 pre-service teachers' analyzing of six classroom situations is related to the format those situations are represented in (text, comic or video). Given the high relevance of dealing with multiple representations in the mathematics classroom, the study focuses on pre-service teachers' competence of analyzing how multiple representations of mathematical objects are used and connected to each other. The results indicate that representations of practice in the formats video, text and comic are comparably suitable for competence assessment in this context.

Keywords Representations of practice · Competence assessment
Video · Comic · Analyzing

Analyzing the Use of Multiple Representations

Due to the double role they play in the mathematics classroom, multiple representations can be described as "aid and obstacle for the learning of mathematics" (Dreher and Kuntze 2015b, p. 26): As mathematical objects are abstract and can only be accessed through representation, the use of multiple representations plays an indispensible role for problem solving and students' conceptual understanding (Duval 2006; Goldin and Shteingold 2001; Goldin 2008; Acevedo Nistal et al. 2009). Being able to use more than one representation of a mathematical object is essential as any representation will express some but not all information of the related mathematical object, stress some aspects and hide others (Dreyfus 2002).

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Many tasks involve at least two representation registers (Duval 2006; Lesh et al. 1987) and dealing with multiple representations becomes necessary whenever another representation appears to be more efficient in the process of problem solving (Dreyfus 2002; Ainsworth 2006).

At the same time, changing between multiple representation registers of a mathematical object (e.g., between algebraic and pictorial representations) is cognitively challenging as the learner must discriminate mathematically relevant features from those that are not relevant in a mathematical sense and transfer the information from one representation register to the other (Duval 2006). Therefore, changes between multiple representations of a mathematical object, so-called *conversions* (Duval 2006), are described as a source of problems in understanding in every domain of mathematics and at every level of teaching (Ainsworth 2006; Duval 2006; Lesh et al. 1987). This is in particular the case when learners are not sufficiently supported in connecting different representations of a mathematical object to each other when they carry out conversions (Duval 2006; Ainsworth 2006).

Consequently, an adequate support of students in making connections between multiple representations of a mathematical object requires that teachers are able to *analyze* how representations are used in the mathematics classroom: Teachers have to be able to identify and interpret situational aspects that are relevant for learning with multiple representations, such as unconnected conversions (Dreher and Kuntze 2015a; Friesen and Kuntze 2016; Friesen et al. 2015). Therefore, professional knowledge regarding the use of multiple representations is required to provide criteria as a basis on which relevant classroom observations can be interpreted (Kuntze et al. 2015; Friesen et al. 2015; Sherin et al. 2011).

As specific and context-dependent abilities to cope with profession-related demands can be described as competences (Weinert 1999; Baumert and Kunter 2013), *analyzing classroom situations regarding the use of multiple representations* can be regarded as an important profession-related competence for mathematics teachers (Friesen and Kuntze 2016). This is also supported by studies showing that such analyzing is an important characteristic of teacher expertise (Dreher and Kuntze 2015a) and can be learned in the context of professional teacher development (Friesen et al. 2015). Accordingly, we define the *competence of analyzing the use of multiple representations* 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. Such competence can be seen as an important prerequisite for mathematics teachers in order to be able to provide students with adequate support in making connections between multiple representations of a mathematical object.

Competence Assessment with Representations of Practice

As profession-related competences are characterised by the range of situations and tasks which have to be mastered, competence assessment should be done by confronting test-takers with a sample of such (simulated) situations (Weinert 1999; Shavelson 2013). Accordingly, representations of practice can be implemented in corresponding test instruments in order to assess competence in close relation to professional requirements of teachers (e.g., Oser et al. 2009). In contrast to direct classroom observations, test instruments making use of representations of practice allow to assess competences under standardised conditions as the test-takers' responses to the same classroom situations become comparable (Kaiser et al. 2015; Oser et al. 2009). In addition, such instruments enable the systematic assessment of competences with larger samples of teachers (Borko 2016).

Many studies in the field of competence assessment argue for the use of video-based representations of practice as video is supposed to allow the perception of meaningful real-life job situations (Blömeke et al. 2015). Furthermore, representations of practice in video format appear to enhance teachers' engagement with classroom situations in terms of perceived authenticity and resonance with own classroom experience (Seidel et al. 2011; Kleinknecht and Schneider 2013). Teachers have also found to be motivated when working with video-based representations of practice and reported high immersion into the presented classroom situations (ibid.). However, recent studies have drawn attention to representations of practice in other formats than video: A comparison between pre-service teachers' analysis of the same classroom situation in the formats video and animation showed that the participants rated the genuineness of the representation significantly higher in the case of video (Herbst et al. 2013). The pre-service teachers' analyzing, however, appeared not to be related to the format the classroom situations were represented in, as corresponding analyzing results did not show any significant differences (ibid.). Herbst et al. (2013) concluded that representations of practice in the animation format might be comparably effective to video in order to elicit pre-service teachers' analyzing.

Another possible format to assess teachers' analyzing of mathematics classroom situations are text-based representations of practice as used by Dreher and Kuntze (e.g. 2015a, b) in order to assess teachers' theme-specific noticing: They applied four short transcript-like texts with fictitious classroom situations to elicit teachers' ability to notice potentially obstructing demands of unconnected changes of representations for students' understanding (ibid.). Similar to text-based representations of practice, comics allow to sketch numerous and systematic variations of a classroom situation that can hardly be found and recorded in reality (Herbst and Kosko 2014). Comic-based representations of practice were, for example, used by Herbst et al. (2016) who implemented cartoon storyboards in order to assess teachers' instructional decision-making.

There are, however, so far only very few studies in the field of competence assessment that are format-aware in the sense that they investigate how teachers

engage with different formats, e.g., in terms of perceived authenticity or if teachers' analyzing of a classroom situation is related to the format it is represented in. In the following, texts, comics and video-based representations of practice will be compared with respect to the assessment of pre-service teachers' analyzing of classroom situations as investigated in this study.

Representations of Practice in Text, Comic and Video Format

Individual characteristics of different formats of representations of practice might play a role for the test-takers' engagement with and analysis of the implemented classroom situations (see Fig. 1). By engagement we mean perceptions of authenticity, immersion, motivation and resonance. In particular, we use the term immersion to describe the effect that representations of practice can provide the test-takers with enough information to be "inside" the presented classroom situation (Seidel et al. 2011). The term resonance describes the effect that representations of practice can facilitate the test-takers ability to relate to their own teaching experiences (ibid.).

To describe how various types of representations of practice can differ, Herbst et al. (2011, cf. Herbst and Kosko 2014) propose the categories of temporality and individuality. Accordingly, videos often reproduce the passing of time and preserve the individual features of people and places in the presented classroom events. Texts, however, neutralise individuality and temporality to a high degree by using

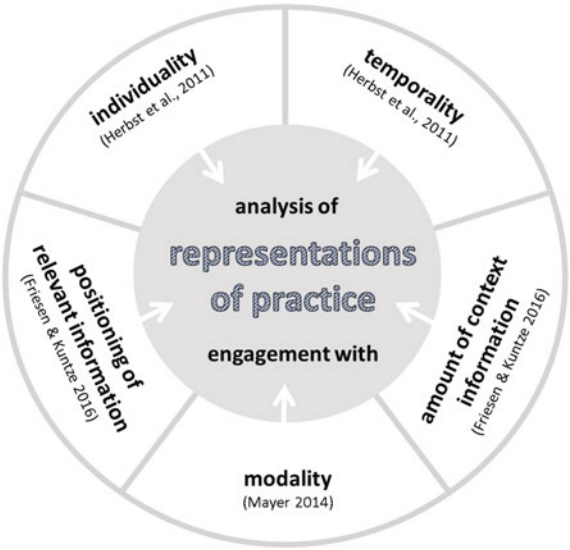


Fig. 1 Key categories for comparing different representation formats (e.g., text, comic, video) and their possible role for the engagement with and analysis of representations of practice

expressions such as "the students" and expand or collapse the duration of the presented classroom situations. The position of comics might be somewhere in between: Regarding temporality, a comic strip with speech bubbles can be compared to a text, whereas regarding individuality, it is closer to video (Herbst et al. 2011).

Other categories describing the characteristics of different representation formats are the positioning of relevant information and the amount of context information in these formats (Friesen and Kuntze 2016) as well as the modality in which such information is provided (cf. Mayer 2014). Whereas text-based representations of practice can present classroom situations in a clear structure, rather lengthy descriptions might be necessary to picture what students and teachers are doing. In videos, the information relevant for the analysis of a classroom situation might be somewhere hidden in the vast amount of context information as visual and acoustic information as well as moving pictures have to be processed. However, the larger amount of context information provided in video-based representations of practice could also support the understanding of a classroom situation and help to perceive it as more authentic and more motivating (Friesen and Kuntze 2016; Seidel et al. 2011). In comics, individual characteristics that might be important to fully comprehend a situation can be added without leading to lengthy descriptions that would be necessary in text-based representations of practice. At the same time, unnecessary context information that might be hindering for the engagement with and analysis of a classroom situation can be left out (Friesen and Kuntze 2016). Low individuality as provided by nondescript characters in comic-based representations of practice might also help to project an observer's individual teaching experience on a classroom situation and could thus facilitate the engagement with a classroom situation in terms of immersion, the perceived authenticity, motivation and resonance (cf. Herbst and Kosko 2014; Seidel et al. 2011).

To our knowledge, there are hardly any empirical studies which systematically investigate the possible role of different formats such as text, comic and video when representations of practice are used in competence assessment. As the individual characteristics of different representation formats might, however, be related to the test-takers engagement and analysis as described above, corresponding research questions are addressed in this study.

Research Interest and Research Questions

The research interest of this study is to explore whether format (text, comic, video) plays a role in assessing pre-service teachers' competence of analyzing classroom situations regarding the use of multiple representations. In particular, the research questions are the following:

- Is there a relationship between the pre-service teachers' analyzing regarding the use of multiple representations and the format of the presented classroom situations (text, comic, video)?
  In particular: Does the format of the represented mathematics classroom situations play a role for the pre-service teachers' ability to identify unconnected changes of representations and to interpret them with respect to their role as potential learning obstacles?
- Is there a difference in the pre-service teachers' engagement with representations of practice regarding the format of the representation (text, comic, video)?
  In particular: Do the pre-service teachers perceive texts, comics and video-based representations of practice differently regarding authenticity or with respect to the pre-service teachers' immersion, motivation and resonance?

Development of the Implemented Representations of Practice

In order to assess the pre-service teachers' competence of analyzing regarding the use of multiple representations, we developed a test instrument involving classroom scenarios situated in grade 6. All representations of practice have a similar structural design and show classroom situations with group work in the context of fraction learning. Each classroom situation starts with the teacher being asked for help by a group of students who have already started to solve a given problem using a certain representation (e.g., algebraic or pictorial). The situations were designed on purpose in such a way that the teachers' support of the students is not in line with the theory regarding the use of multiple representations as outlined above. In attempt to support the students' understanding, the teacher shifts away from the representation the students have already been using and changes to an additional representation. However, this change of representations remains unexplained as the teacher fails to connect it to the representation the students have already been using. Due to the lack of connections between the different representations the students and the teacher make use of, the teacher's reaction could potentially lead to further problems in the students' understanding rather than supporting it (Friesen and Kuntze 2016).

With the aim to explore validity of the designed representations of practice described above, the classroom situations were presented to $N = 5$ expert teachers who are not only experienced practitioners but also hold positions as teacher educators for pre-service teachers who are in their induction phase at secondary schools. Therefore, these expert teachers can be expected to be well experienced in observing and analyzing classroom situations. They were separately asked to evaluate the teacher's reaction to the students' question regarding the use of multiple representations in each classroom situation. In addition, the expert teachers judged the authenticity of the designed classroom situations, for example regarding

the questions the students asked and the representations that were used by students and teachers. According to these expert ratings, six classroom situations were chosen for the test instrument in which the support given by the teachers was identified as potentially impeding for the students' understanding due to the unexplained and unconnected change of representations as outlined above. These classroom situations were also rated as highly authentic and representative for mathematics classrooms in grade 6 by the experts.

In order to investigate the pre-service teachers' responses to different formats, we implemented each of the six classroom situations as text, comic and video (see Fig. 2 for an example). The texts were used as blueprints to design the comics and the comics provided the storyboards for the video recordings. In order to avoid dependencies between the video clips, each video was recorded in another classroom showing six different teachers and learning groups. After editing the video recordings, we adapted the comics and the texts, so that the conversations in the classroom situations would have the same wording in each format and the representations used by students and teachers (e.g., fraction circles) would look the same (Friesen and Kuntze 2016).

In order to provide more insight into the content and plot of the representations of practice implemented in the test instrument, one of the classroom situations will be described in more detail in the following (see Fig. 3).

In this classroom situation, the students struggle with converting an improper fraction into a mixed number. They have already started to solve the problem by changing registers, namely from the given register of representation (fraction number $\frac{13}{5}$) to a division (13:5). As they do not know how to continue, the teacher explains that they can write the remainder of the division as a fraction. As this idea involves a conversion from the division register (13:5 = 2R3) back to the fraction register ($2\frac{3}{5}$), which the students obviously are not able to carry out, the teacher introduces two further registers of representation: The problem is now represented in a real-world situation where thirteen pizza slices are put together in a way that they form two whole pizzas and three slices. While telling the pizza story, the

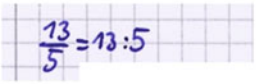
Fig. 2 Representations of practice in text, comic and video format; comic drawn by Juliana Egete

PRACTICE LESSON GRADE 6: Rewriting improper fractions as mixed numbers

S1: Can you please help us here? We have a question…

(Teacher comes to the students' desk.)

S2: We want to rewrite this fraction as a mixed number. And because the fraction bar means the same as dividing, we have started to write it like this *(shows entry in their notes).* But we don't know how to go on now…

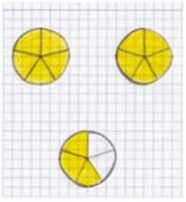


T: Ok, we call this a division with a remainder and, as you know, you can write the remainder as a fraction.

S2: Well, honestly, I still don't get it…

T: Let's explain it with a pizza then, ok? I'll make a quick drawing for you.

(Teacher draws and explains.)



T: Here you have 13 pizza slices. And now we put them together: five slices make one whole pizza. Then you get two pizzas and three slices are left: Two wholes and three fifths!

Fig. 3 Representation of practice in text format

teacher uses another register of representation by drawing fraction circles that stand for the pizzas. The situation finishes with the teacher verbally providing a mixed number as the solution to the initial problem: "Two wholes and three fifths". On the surface, it seems that the teacher's support has finally led to the correct solution of the given problem. Moreover, the teacher's idea to move away from symbolic representations to the potentially motivating pizza story and colored fraction circles seems to be a student-oriented approach.

However, analyzing this classroom situation against the theoretical background of dealing with multiple representations in the mathematics classroom leads to a different result. Throughout the situation, the students are hardly supported in relating different registers of representations to each other when changes of representations occur: The first conversion from the fraction to the division register is

initiated by the students themselves, but they cannot complete it. Instead of supporting the students in doing so, the teacher changes registers again by introducing the pizza story and the circular pies, however, without making any connections to the registers used before. It remains, for example, unexplained why there are thirteen pizza slices and why always five slices make one whole. The problem is finally solved by the teacher in the "pizza" register, again without making any connections back to the registers the students were struggling with at the beginning of the situation. The teacher does not explain, for example, how the solution "two wholes and three fifth", which is only verbally expressed, is related to the solution in the pizza register (two whole pizzas and three slices are left) or in the division register (2R3), where fifths do not appear at all. For these reasons, the teachers' reaction can hardly be regarded as a support for students' understanding, but might rather be seen as a potential obstacle for the successful integration of multiple registers of representation in the process of students' learning of fractions.

Although the corresponding text, comic and video represent the same classroom situation (see Fig. 2), they differ from each other regarding aspects of individuality, temporality (Herbst et al. 2011), modality (Mayer 2014), the positioning of relevant information regarding multiple representations and the amount of context information in general (Friesen and Kuntze 2016). Text-based representations require to get engaged with the classroom situations while only providing basic information and little individuality. As such, text-based representations might help pre-service teachers to focus their analysis on the use of multiple representations. The reduced amount of context information might, on the other hand, make it difficult to immerse into the situation and could make a situation look less authentic.

In contrast, a video-based representation of practice provides high individuality showing concrete students, teachers and classrooms which might contribute to the perceived authenticity of a situation and might be particularly motivating for the pre-service teachers. Analyzing a video-based representation of practice could, however, be more difficult as the shown teacher explains and draws at the same time so that visual and acoustic information has to be perceived simultaneously with a temporality close to a real classroom situation.

The analysis of comic-based representations of practice requires from the pre-service teachers to connect graphical elements (comic storyboard, depicted representations such as the fraction circle) to the text in the speech bubbles in order to make sense of the classroom situation. The reduced amount of context information, in contrast to the video-based representation of practice, might help to focus the analysis on the use of multiple representations.

Sample, Design and Administration of the Test Instrument

The sample of this study consists of $N = 162$ mathematics pre-service teachers (66.9% female; $M_{age} = 21.55$, $SD_{age} = 2.38$) in the first three semesters of their professional teacher education ($M_{semester} = 1.80$; $SD_{semester} = 1.40$). All student

teachers were enrolled in courses for teaching mathematics at secondary school level and came from different Universities of Education in the State of Baden-Wuerttemberg, Germany. They completed the test instrument described above in a course at their home university.

In order to assess the pre-service teachers' competence of analyzing the use of multiple representations, they were asked to evaluate the teachers' support in each of the six classroom situations by responding to the following open-ended item: *How appropriate is the teacher's response in order to help the students? Please evaluate the use of representations and give reasons for your answer.* With the aim to investigate the role of the different formats for the pre-service teachers' engagement with the classroom situations and for their analyzing the use of multiple representations, a multiple matrix design comprising of six test booklets was applied (see Table 1). Each booklet included the six classroom situations while always two situations were implemented in the same format. The links amongst the booklets can be seen in Table 1: Always two booklets were linked to each other by sharing the same cluster of three representations of practice. Thus, a balanced distribution of the six classroom situations in the three formats could be achieved (Friesen and Kuntze 2016). The test booklets were randomly assigned to the pre-service teachers. The videos lasted about 1.5 min each and could be paused or watched several times.

With the aim to investigate how authentic the pre-service teachers found a given classroom situation and how they perceived their motivation, immersion and resonance when dealing with it, they were asked to evaluate their engagement with

Table 1 Multiple matrix booklet design (T ≙ text, C ≙ comic, V ≙ video)

Classroom situation	Booklet 1	Booklet 2	Booklet 3	Booklet 4	Booklet 5	Booklet 6
1	T	T	C	C	V	V
2	C	C	V	V	T	T
3	V	V	T	T	C	C
4	T	V	V	C	C	T
5	C	T	T	V	V	C
6	V	C	C	T	T	V

Table 2 Rating scale statements related to the pre-service teachers' engagement (cf. Seidel et al. 2011)

Engagement (in terms of)	Sample item
Authenticity	*The classroom situation appeared as authentic to me*
Immersion	*I felt part of the situation, as if I had been there in the classroom*
Motivation	*I found it motivating to deal with the classroom situation*
Resonance	*Dealing with the situation made me think of my own classroom experience*

each of the six situations (cf. Seidel et al. 2011). Therefore, the pre-service teachers evaluated four statements (see Table 2) according to a six-point Likert scale (1 = *I strongly disagree*; 6 = *I strongly agree*) after analyzing a classroom situation regarding the use of multiple representations.

Data Analysis and Selected Results

Addressing the first research question regarding the pre-service teachers' analyzing of the six classroom situations, their answers were coded by two independent raters reaching a good inter-rater reliability with $\kappa = 0.85$ (Cohen's kappa). The top-down coding scheme was derived from how we defined the competence of analyzing the use of multiple representations, namely as the ability to identify unconnected and unexplained conversions in classroom situations and interpret them as potential learning obstacles. Accordingly, code 0 was assigned to answers that referred only to representations used by the teacher without making any connections to the students' question or the representation used by the students, thus indicating that the unconnected change of representations has not been identified (see Fig. 4 for a corresponding coding sample).

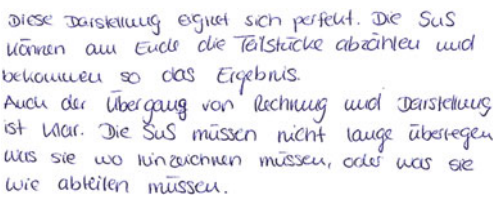
Code 1 was assigned to answers indicating that a pre-service teacher has identified the change of representations, however, without mentioning that it remains unconnected and might consequently be problematic for students' understanding (see Fig. 5 for a corresponding coding sample).

Code 2 was assigned to pre-service teachers' answers indicating that the unconnected change of representations has been identified and interpreted with respect to its role as potential learning obstacle (see Fig. 6 for a corresponding coding sample). Code 2 was thus taken as indicator for the competence of analyzing the use of multiple representations in a classroom situation. All coding samples (see Figs. 4, 5 and 6) refer to the classroom situation shown in Fig. 3.

The distribution of the three codes (see Fig. 7) shows that only 25.1% of the pre-service teachers' answers indicated that the unconnected change of representations has been identified and interpreted with respect to its role as potential learning obstacle.

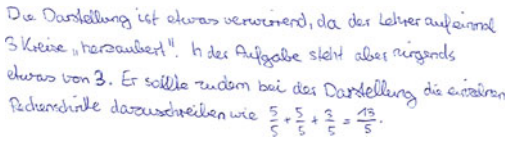
Die Darstellung der Lehrperson finde ich gut. Schülerinnen und Schüler können sich Brüche mit Hilfe von Pizzas gut vorstellen. Die Abbildungen sind praxisnah und nicht so abstrakt.	I think the teacher's representation is good. Pizzas can help students to get a clear idea of fractions. The drawings are close to everyday life and not too abstract.

Fig. 4 Coding sample for code 0 (pre-service teacher A)


Diese Darstellung eignet sich perfekt. Die SuS können am Ende die Teilstücke abzählen und bekommen so das Ergebnis.
Auch der Übergang von Rechnung und Darstellung ist klar. Die SuS müssen nicht lange überlegen was sie wo hinzeichnen müssen, oder was sie wie abteilen müssen.

This representation is ideal. The students can count the slices at the end and will get the solution. The shift from the calculation to the (graphical) representation is also clear. The students don't have to think long about what goes where or what should be divided how.

Fig. 5 Coding sample for code 1 (pre-service teacher B)


Die Darstellung ist etwas verwirrend, da der Lehrer auf einmal 3 Kreise „herzaubert". In der Aufgabe steht aber nirgends etwas von 3. Er sollte zudem bei der Darstellung die einzelnen Rechenschritte dazuschreiben wie $\frac{5}{5}+\frac{5}{5}+\frac{3}{5}=\frac{13}{5}$.

The (graphical) representation is somewhat confusing because the teacher comes up with 3 circles "as if by magic". There is, however, no "3" in the task. He (the teacher) should also write down each step next to the (graphical) representation:

$$\frac{5}{5}+\frac{5}{5}+\frac{3}{5}=\frac{13}{5}$$

Fig. 6 Coding sample for code 2 (pre-service teacher C)

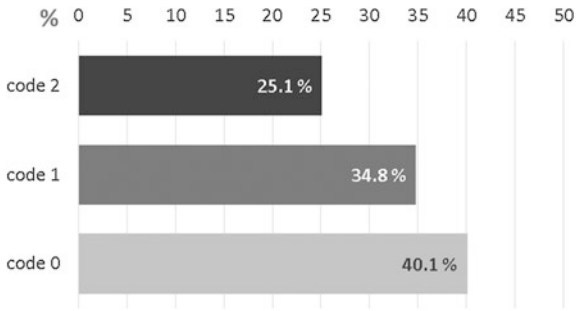


Fig. 7 Pre-service teachers' answers: distribution of codes (cf. Friesen and Kuntze 2016)

In order to address the question of format in a first step, a chi-square test was computed to explore if the pre-service teachers' analyzing results as reported above (see Fig. 7) were related to the format of the classroom situations (text, comic, video). The results of the chi-square test revealed no significant association between the codes and the format in which the classroom situations were presented to the pre-service teachers ($\chi^2(4) = 7.09,\ p > 0.05$).

With the aim to address the question of format in further analyses, a Rasch model was applied to the data of this study for two important reasons. First, the format of a

classroom situation (text, comic or video) can increase or decrease the demands that are required to analyze it (e.g., Hartig 2008). Hence, the empirical item difficulties calculated in the Rasch model are particularly useful to investigate possible relations between the pre-service teachers' analyzing and the format of the classroom situations. The second reason is that the Rasch model provides a mathematical framework against which data can be compared with respect to unidimensionality (Bond and Fox 2015). For this purpose, residual-based fit statistics can be used to determine how well each item fits within the underlying test construct and whether the requirement for unidimensionality holds up empirically (ibid.). This can not only be regarded as a control of the quality of the measures (Bond and Fox 2015) but can also be seen as an important indicator regarding the question of format raised in this study, since different demands involved in analyzing representations of practice in different formats (text, comic, video) might not only lead to significant differences in item difficulties but could also cause items to measure different latent traits or dimensions (e.g., Rauch and Hartig 2010).

In order to conduct the Rasch analysis and estimate the empirical item difficulties of the representations of practice in the different formats, the six classroom situations in the three formats were taken as 18 items. In order to reflect the coding of the pre-service teachers' answers (see Fig. 7), a partial credit model was applied to the data. The Rasch analysis revealed good fit values for all 18 items ($0.91 \leq wMNSQ \leq 1.16$; $-0.6 \leq t \leq 1.0$) indicating that they sufficiently fit the Rasch model (Bond and Fox 2015). The EAP/PV-reliability was obtained by dividing the variance of the individual expected a posteriori ability estimates by the estimated total variance of the latent ability (Wu et al. 2007). It appeared to be rather low (0.45) which might be due to the comparatively small number of items (Bond and Fox 2015). However, it can also be due to the fact that analyzing the classroom situations implemented in the test instrument was quite difficult for the pre-service teachers at the beginning of their university studies, as has already been reflected in the distribution of codes as described above (see Fig. 7).

As the difficulty estimates of the items can be interpreted as interval data (Bond and Fox 2015), an analysis of variance (ANOVA) could be conducted in order to investigate the association of the estimated item difficulties and the different formats of the six classroom situations (text, comic and video). The results of the ANOVA showed no significant effect of format on the item difficulties ($F = 0.047$, $df = 4$; $p = 0.996$), indicating that the pre-service teachers' analyzing of the use of multiple representations was not systematically related to the format of the representation. These findings are hence in line with the results of the chi-square test reported above.

Addressing research question two, the pre-service teachers' evaluations regarding their engagement with the representations of practice were explored. Mean values between $M = 4.0$ ($SD = 1.3$, resonance to videos) and $M = 4.9$ ($SD = 0.9$, authenticity of comics) indicate on average positive ratings with respect to the authenticity of the representations of practice and the pre-service teachers' perceived immersion, motivation and resonance while dealing with the classroom situations (see Fig. 8).

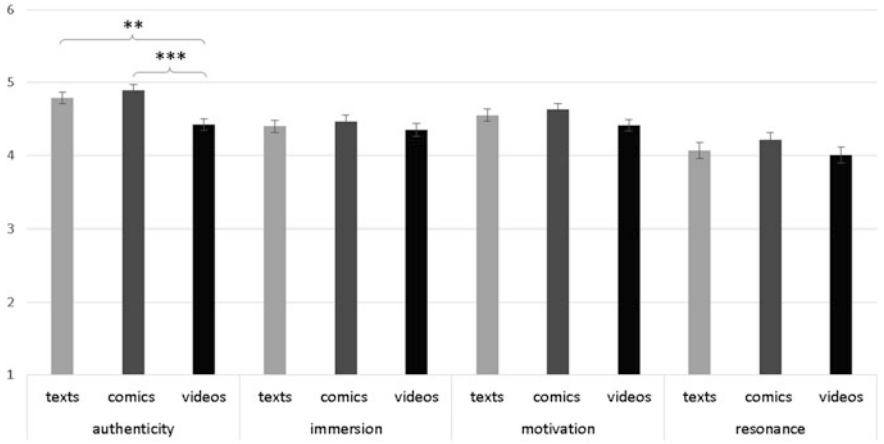


Fig. 8 Pre-service teachers' evaluations regarding their perceived engagement with the classroom situations (means and standard errors, 1 ≙ I strongly disagree/6 ≙ I strongly agree)

In order to investigate the possible role of format for the pre-service teachers' perceived engagement, an analysis of variance (ANOVA) was conducted. It revealed a small but significant effect ($F = 9.897$, $df_1 = 2$, $df_2 = 12$, $p < 0.001$; $r = 0.20$) of the format on the perceived authenticity, indicating that video-based representations of practice were on average rated as less authentic ($M_{video} = 4.4$, $SD_{video} = 1.1$) than texts ($M_{texts} = 4.8$, $SD_{texts} = 0.9$) and comics ($M_{comics} = 4.9$, $SD_{comics} = 0.9$). No significant differences were found between the ratings of texts, comics and videos with respect to the pre-service teachers' perceived immersion, motivation and resonance (see Fig. 8).

Discussion

The aim of this study was to contribute to the methodological question of format when representations of practice are used in research into aspects of teacher competence. Focusing on teachers' competence of analyzing the use of multiple representations in mathematics classroom situations, the question was raised if pre-service teachers' engagement with classroom situations and their analyzing of it are related to the format in which those classrooms are represented in a test instrument. The multiple matrix design of the study made is possible to compare the results of pre-service teachers' analyzing for the same six classroom situations in the three formats text, comic and video, each playing an important role in recent studies assessing aspects of teacher competence. Although the limitations of the study have to be taken into consideration when interpreting the results (e.g., the sample is not representative and is restricted to pre-service teachers, the classroom situations focus on learning of fractions in grade 6, the investigated formats are

restricted to text, comic and video), the research questions could be answered and some implications for further research settings in the field of competence assessment with representations of practice can be derived.

The results show that pre-service teachers engage comparably well with representations of practice in the formats text, comic and video with regard to the perceived motivation, immersion and resonance. In the case of authenticity, the video-based representations of practice were rated significantly lower than the texts and comics (see Fig. 8). These findings contrast, for example, with findings by Herbst et al. (2013) who found that a video-based representation of practice was perceived significantly more genuine by pre-service teachers than the same representation of practice in animation format. The lower ratings of the authenticity revealed in the case of the video-based representations of practice might be due to specific characteristics of the video clips: The high individuality in the videos might, for example, decrease the perceived authenticity when the classroom surroundings differ widely from those familiar to a participant. Furthermore, individual characteristics of the students and teachers in the video clips (e.g., complexion, way of speaking) might diminish the perceived authenticity. Another reason for the lower ratings regarding the authenticity of the video-based representations of practice might be that the clips implemented in the test instrument were staged videos whereas the participants might have expected to see recordings of real classrooms. Further research in this context should also consider the reverse way of designing the different formats text, comic and video by generating texts and cartoons on the basis of recordings from real classrooms.

However, the overall positive mean values of the perceived immersion, motivation, resonance indicate that the participants were sufficiently engaged with the representations of practice implemented in the test instrument, regardless of format. The findings of this study are thus in line with the results found by Seidel et al. (2011) in the case of video-based representations of practice. They add to these findings by showing that with regard to pre-service teachers' engagement with representations of practice, texts and comics can be comparably effective to tap into the competence of analyzing mathematics classroom situations.

The results regarding the pre-service teachers' analyzing of classroom situations presented in the three different formats show that there are no significant differences between the item difficulties related to texts, comics and videos. Furthermore, no significant association between the distribution of the codes for the pre-service teachers' analyzing results and the different formats of the classroom situations (text, comic, video) could be found. In line with these findings, the Rasch model applied to the data showed good fit values indicating that the requirement for unidimensionality holds up empirically and that all items contribute in a meaningful way to the competence of analyzing, regardless of format. It can thus be concluded that the pre-service teachers' analyzing of the use of multiple representations was not systematically related to the specific characteristics of the different formats (text, comic, video) as have been described above. These findings are in line with results reported by Herbst et al. (2013), showing that pre-service teachers' analyzing of a classroom situation was not associated with the implemented formats video and

animation. The findings of the study presented here can add to these results, as the multiple matrix design made it possible to compare six classroom situations in three formats (text, comic, video). It can be concluded that videos, texts and comic-based representations of practice were comparably suitable to elicit pre-service teachers' analyzing regarding the use of multiple representations in mathematics classroom situations.

Bearing in mind the high expense involved in the production of video-based representations of practice, the findings of this study encourage further research into the development of alternative formats in order to assess profession-related competences of teachers. They add to findings in the field of video-based measurement which were, for example, made by Santagata et al. (2007) and Kaiser et al. (2015) and encourage the use of representation formats other than video when aspects of teacher competence are assessed. When test instruments involving representations of practice are developed, it should particularly be taken into account whether specific characteristics inherent to a certain format are suitable to facilitate the analysis of a presented classroom situation or whether such characteristics could also impede analyzing. However, certain characteristics of formats, such as a high degree of temporality or high amount of context information, might also be implemented by purpose when they form a part of the professional competence under investigation. In future research, pre-service teachers at an advanced level and in-service teachers should be taken into account as they might perceive texts, comics and video-based representations of practice in a different way, due to their different professional knowledge and teaching experience.

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