

Assessing pre-service teachers' competence of analysing learning support situations through a multi-format test instrument comprising of video, comic, and text vignettes

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When assessing teachers' competence of analysing specific classroom situations, the representation format of the classroom situation might impact on the quality of the teachers' answers. However, relatively little is known about the role of, for example, video, comic or transcript-like text formats in assessment instruments. This paper consequently focuses on this research need and presents results from a study which uses a format-aware design. For facilitating connections with prior research, more than 160 pre-service teachers were asked to analyse the use of representations in six learning support situations. The findings support the empirical unidimensionality of the competence construct under Rasch analysis while taking into account the three different representation formats of the classroom situations.

Keywords: vignette-based assessment, competence of analysing, noticing.

INTRODUCTION

Teachers have to draw on their resources (Schoenfeld, 2011) when they need to analyse observations in the classroom – at the same time, the competence of analysing is in itself an important resource of mathematics teachers (cf. Kuntze, Dreher & Friesen, in press): In learning support situations, for instance, teachers have to link criterion knowledge with observations, in order to analyse whether a reaction to a students' question is helpful. A key area of such criterion knowledge is knowledge related to the use of representations in the classroom (Dreher & Kuntze, 2015a), as it is a prerequisite for effectively analysing whether students might encounter problems with e.g. unnecessary changes of representations or with the potential disconnectedness of representation registers. However, the format in which a classroom situation is presented to teachers might make a difference: Whereas Dreher & Kuntze have used text vignettes only, Herbst, Aaron & Erickson (2013) have compared video and animation formats, i.e. formats marked by temporality. To our knowledge, there is hardly any empirical study which is “format-aware” in the sense that the design includes multiple formats (text, comic, video) and the possibility of taking into account their role in the corresponding measurement instrument.

Correspondingly, in order to establish validity with this respect, this study makes an attempt of assessing teachers' competence of analysing the use of representations with a multi-format test instrument coupled with a multi-matrix design in the

assignment of formats to teachers, so that the role of the format can be taken into account.

We will in the following give an overview of the theoretical background, present the research questions, inform about design and sample, report about key results and discuss them in a concluding section.

THEORETICAL BACKGROUND: THE COMPETENCE OF ANALYSING THE USE OF REPRESENTATIONS IN THE CLASSROOM

According to Duval (2006), mathematical objects are only accessible through representations that can stand for them in many different ways (Goldin & Shteingold, 2001). In this sense, multiple representations often complement each other and emphasise different facets of the same mathematical object (Duval, 2006). For building up a rich concept image of a mathematical object (Ainsworth, 2006) which facilitates flexible ways of problem solving (Lesh, Post & Behr, 1987), learners have to integrate multiple representations. This points to the core role of changes between different representation registers (Duval, 2006): Changing representations is at the same time a valuable learning opportunity and a potential learning obstacle, as it is cognitively complex and often leads to difficulties in understanding (Ainsworth, 2006; Duval, 2006). Students thus should be supported when dealing with multiple representations: reflecting on and creating connections between different representation registers plays a key role (Duval, 2006; Bodemer & Faust, 2006) and unreflected changes of teachers between disconnected representations may cause understanding problems of students (Sjuts, 2002).

Consequently, teachers have to master the professional requirement of identifying and interpreting relevant observations regarding the use of representations in the classroom (Friesen, Dreher & Kuntze, in press). In particular, for reacting adaptively and optimally to the learners' needs, teachers should be able to analyse how changes between representations take place. Such analysing of classroom situations means that observations are connected with relevant professional knowledge – for instance, specific criterion knowledge may be used for the observations' interpretation (e.g. Dreher & Kuntze, 2015a; Friesen, Dreher & Kuntze, in press).

Analysing classroom situations regarding the use of representations is hence an important competence for mathematics teachers: professional competencies in Weinert's (1999) definition are specific and context-dependent abilities to cope with professional requirements, which is clearly the case here. Studies showing that such analysing is an aspect of teacher expertise (Dreher & Kuntze, 2015a) and that it can be fostered through focused professional development activities (e.g. Friesen, Dreher & Kuntze, in press) further support the relevance of this competence construct.

We see the competence as a hierarchical and one-dimensional variable, as the criterion knowledge (e.g. Duval, 2006) can be seen as a consistent unit which can be applied for analysis in various contexts. The requirements of the situation contexts

however may differ in complexity, as teachers might have different preferences for specific representation registers which can interfere with analysis steps (cf. qualitative findings in Dreher & Kuntze, 2015a), i.e. support or impede a critical analysis of the use of representations in the classroom interaction. For instance, we found examples of teachers who were very in favour of a specific representation register and who were not aware of the problem of disconnectedness between representations when the (unnecessary) change into this favoured representation register occurred – their preference of representation registers was so dominant that they did not enter in a criteria-based analysis process (Dreher & Kuntze, 2015a). We conclude from these findings that it might be more difficult for teachers to analyse the use of representations when the registers used by the teacher observed in the classroom situation are among the commonly favoured representation registers.

The role of the representation format of the classroom situation to analyse

Another issue which might influence the complexity of analysing the use of representations in the classroom is the way the classroom situation is represented. As it is almost impossible to reproduce *real* classroom situations identically, classroom situations have to be somehow represented in order to make them available for assessment. Figure 1 shows three representation formats, namely a transcript-like text format, a comic format and two screenshots from a video format representation of the same situation. It is obvious that these formats provide different information, and that they make available identical information elements in different ways. Even if the three representations of this learning support situation have been produced in a structured procedure which aimed at eliminating any contradictions such as different wording or different drawings of representations (cf. Friesen & Kuntze, in press), there are important systematic variations among the different representation formats: Temporality, for instance, makes a difference between video format on the one side and text and comic formats on the other side: For example, the speed issue in interaction is much less visible in a comic and in a transcript. Moreover, the formats

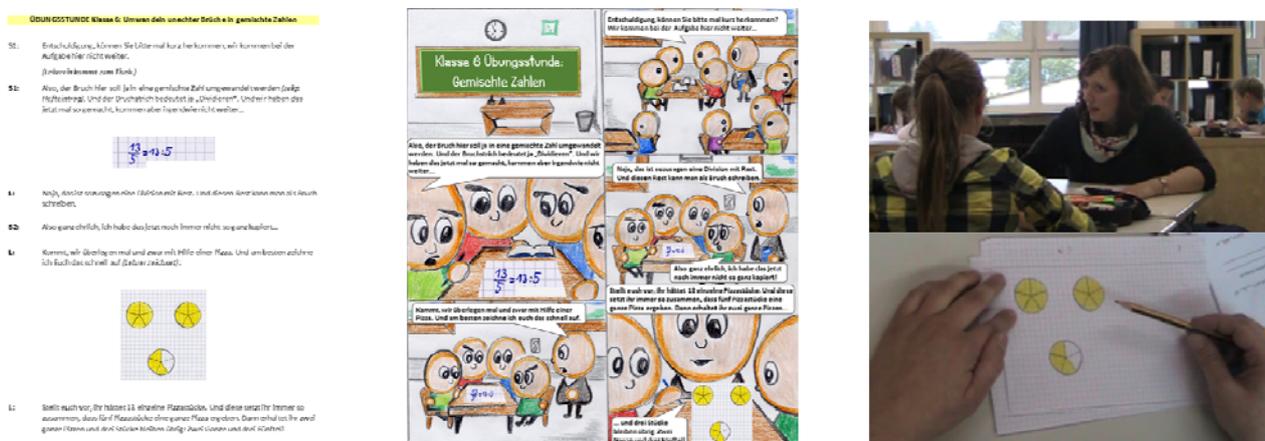


Figure 1: Representation of a learning support situation in transcript-like text, comic and video format (comic drawn by Juliana Egete)

differ in the amount of potentially relevant and irrelevant context information. It might make a difference for the analysis if, for example, the characters in the comic format were all smiling, whereas the colour of the furniture in the background is rather irrelevant for the analysis – and invisible in the text format, for instance. The individual persons in the classrooms are almost absent in the text format, whereas they are more visible in the comic format and appear as real human beings in the video. According to Weinert (1999), aspects of teacher competence are of contextualised nature, so that the amount and methods of contextualisation in vignettes used in assessment instruments may play a role. When assessing competence by referring to professional requirements of teachers as reflected in vignettes (Oser, Salzmann & Heinzer, 2009), format might matter. Even if many researchers discuss the potential of video-based forms of assessment (e.g. Blömeke, Gustafsson & Shavelson, 2015; Seidel et al., 2011; Sherin et al., 2011) there are only very few studies like e.g. the study by Herbst & Kosko (2013) and Herbst, Aaron & Erickson (2013), in which different formats are compared empirically and systematically.

We see analysing as “*an awareness-driven, knowledge-based process which connects the subject of analysis with relevant criterion knowledge and is marked by criteria-based explanation and argumentation*” (Kuntze, Dreher & Friesen, in press). Classroom situations as represented in different formats can be such subjects of analysis. We assert that the process of analysing is not linear (Friesen, Dreher & Kuntze, in press). In any case, in the teachers’ answers, only the results of the analysis will be visible – perhaps only in parts. However, as our focus is on the *competence* of analysing regarding a specific area of criterion knowledge, namely the use of representations, and as the articulation of analysis results is part of this competence, the teachers’ answers are very informative. When assessing this competence, we have to be aware that both different classroom situations and format might influence the complexity of vignettes. For this reason, research designs should take this potential interaction into account, so that the potential impact of the representation format is not confounded with the competence construct.

Moreover, among the teachers’ perceptions of the vignettes, there might also be other extraneous disturbing factors for analysis: If, for instance, teachers do not perceive a vignette as authentic, this might be detrimental to getting engaged with the corresponding classroom situation. Under this perspective, motivation might play a role as well. The extent to which teachers feel part of the classroom situation or to which they feel to be able to connect with their experience can be considered as further indicators for the facility of teachers’ engagement with a classroom situation. For this reason, an assessment instrument should also be aware of perceptions such as authenticity, motivation, immersion, and resonance (e.g. Seidel et al., 2011; Kleinknecht & Schneider 2013).

As the instrument was intended to describe teacher growth during initial teacher professional development, this study focuses on pre-service teachers. From an earlier study with a pilot-like vignette-based subtest (e.g. Dreher & Kuntze, 2015a, b), we were able to extract also expectations related to other possible samples.

RESEARCH INTEREST

In contrast with the key role of representations in the mathematics classroom, empirical evidence about the competence of analysing the use of representations is scarce. Against the background of the considerations above, assessment instruments are needed which take into account the potential role of representation formats. Moreover for such an instrument, it should be examined whether teachers' perceptions are positive as far as authenticity, motivation, immersion, and resonance are concerned.

Consequently, this study aims to find out whether an assessment instrument comprising of vignettes in text, comic, and video format can be used to empirically describe the competence of analysing classroom situations regarding the use of representations empirically with one competence dimension.

In particular, the following research questions are in the foreground:

- (1) Do the pre-service teachers rate authenticity, motivation, immersion, and resonance related to the vignettes as positive?
- (2) Can the competence of analysing the use of representations in classroom situations be empirically described by a one-dimensional Rasch model?
- (3) Are there any systematic differences in the empirical difficulty of vignettes for different vignette formats (text, comic, video)?

DESIGN AND SAMPLE

For assessment, six classroom situations were conceived which all consisted of learning support situations in year 6. According to the situations' design, they start with the teacher being asked for help by a group of students who have a difficulty with solving a given problem and who are using a certain representation (algebraic or pictorial). The teacher reacts with a change of representation without connecting with the representation of the students or encouraging reflection about the connections of the two representations. So in all six cases the reaction is non-optimal according to the theory about the use of representations as outlined at the beginning of this article. The change of representations could for this reason potentially lead to further problems in the students' understanding rather than support it.

These learning support situations were each represented in the formats of transcript-like texts, comics and videos (cf. Fig. 1). After producing the video vignettes, the text and comic formats were adjusted so that the wording of the dialogues and the fraction representations were congruent (Friesen & Kuntze, in press). For each vignette, the

pre-service teachers were asked to what extent the teachers' reaction helped the students regarding the use of representations. The participants' open format answers were coded according to a theory-based top-down categorisation: code "0" was assigned to the answer if it referred at most to representations used by the teacher without making any connections to the students' question/representation, code "1" was used when the answer referred to representations used by both students and teacher and did not mention that the unexplained change of representations might be problematic, and code "2" stands for answers which referred to representations used by both students and teacher and mentioned that the unexplained change of representations might be problematic. The pre-service teachers' answers were coded independently by two raters with good inter-rater reliability (Cohen's $\kappa=0.85$).

Moreover for each vignette, the pre-service teachers were asked to answer rating scale indicator items for authenticity, motivation, immersion, and resonance which were adapted from the study of Seidel et al. (2011).

The pre-service teachers were asked to comment on each of the six situations. In a randomised way, each participant received one out of six test booklets as shown in Figure 2, so that the vignette formats were rotated according to a multi-matrix design. The videos were about 1.5 minutes long and could be paused and repeated.

Test booklet number	I	II	III	IV	V	VI
Situation 1	Text	Text	Comic	Comic	Video	Video
Situation 2	Comic	Comic	Video	Video	Text	Text
Situation 3	Video	Video	Text	Text	Comic	Comic
Situation 4	Text	Video	Video	Comic	Comic	Text
Situation 5	Comic	Text	Text	Video	Video	Comic
Situation 6	Video	Comic	Comic	Text	Text	Video

Figure 2: Overview of the six test booklets with rotated vignette formats

The sample consisted of 162 pre-service mathematics teachers (66.9% female; aged on average 21.55 years (SD=2.38)). The pre-service teachers were at the beginning of their professional education (average number of semesters: 1.80 (SD=1.40)).

RESULTS

An important prerequisite for the pre-service teachers' engagement with the learning support situations is that they see the vignettes' authenticity positively, that they are motivated when reflecting about the vignettes, and that they can personally imagine to be part of the situations (immersion) as well as find it possible to connect to their prior classroom experience (resonance). The average ratings concerning these

variables were all positive, regardless of the particular classroom situation and representation format, respectively (mean values ranging from 4.1 to 4.7 on a scale from 1 to 6, SD ranging from 0.8 to 1.2). For the first research question, we may hence state in particular that none of the classroom situations was seen as non-authentic and that also from the point of view of the other variables no impeding factors for analysis could be identified.

For answering the second research question, the pre-service teachers' answers were coded and a score per item was assigned according to the codes. Taking all items together, only 25.1% of the answers mentioned the unexplained change of representations and evaluated this change of representation as potentially problematic (corresponding to code "2"). A chi-square test revealed that there was no significant correspondence of vignette format (text, comic, video) and the pre-service teachers' analysis scores related to the classroom situations ($\chi^2(4) = 7.09$).

Based on the codes assigned to the answers, we applied a partial credit Rasch model as partial marks were awarded in an ordered way according to the top-down coding (cf. Bond & Fox, 2015). The six vignettes in the three formats were considered as one item each, resulting in 18 items altogether. The Rasch analysis revealed good fit values for all 18 items ($0.91 \leq wMNSQ \leq 1.16$; $-0.6 \leq T \leq 1.0$), so that all of them fitted sufficiently to the Rasch model (Bond & Fox, 2015). Consequently, the results indicate that the Rasch requirement for unidimensionality is fulfilled empirically and that each item contributes meaningfully to the competence of analysing as implemented in the test instrument. The EAP/PV reliability amounts to 0.45, which is rather low, but this has to be seen against the background of missing data by design (see multi-matrix design in Fig. 2) and of the comparatively small number of items, so that the reliability value can be considered as satisfactory (Bond & Fox, 2015).

The Wright map (Figure 3) displays both items and persons located on the same competence dimension (highest values located on the right of the logit scale). As a consequence of the polytomous scoring (codes 0, 1, 2), the Wright map contains two difficulty thresholds per vignette: above threshold estimate 1, scoring code 1 is more likely than scoring code 0 and above threshold estimate 2, scoring code 2 is more likely than scoring code 1 (Bond & Fox, 2015).

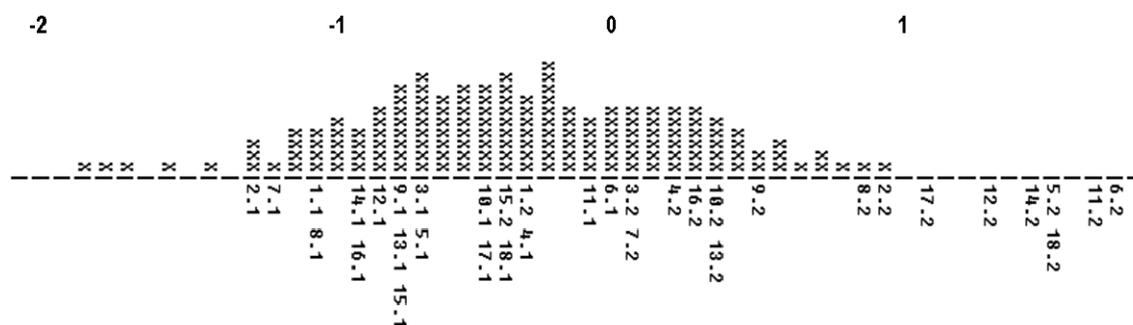


Figure 3: Wright map of the partial-credit Rasch model

Looking at the item difficulty estimates for all 18 items, it can be remarked that the step between code 0 and 1 is empirically easier (mostly negative logit scores) than the step between code 1 and 2 (mostly positive logit scores) – this is consistent with the expectation. The distribution of the persons does not exceed the range of the most difficult thresholds – also this finding conforms our expectations about samples of pre-service teachers at the beginning of their professional education (cf. Dreher & Kuntze, 2015b, as mentioned above).

Turning to the third research question, the Wright map suggests that the presentation format of the six learning support situations does not make a systematic difference for empirical item difficulty. If, for instance, the video vignettes had been more difficult than other vignettes, then the video vignette difficulty thresholds would have systematically appeared more to the right than their comic- and text-format counterparts, which is not the case in the Wright map in Figure 3.

The difficulty estimates can be interpreted as interval data (Bond & Fox, 2015), so that analyses of variance can be calculated for checking whether there is an association of item difficulty and vignette format. In line with the chi-square test reported above, the comparison of text vignettes (items 1-6), comic vignettes (items 7-12) and video vignettes (items 13-18) did not yield any significant format-related differences ($F=0.047$, $df=4$; $p=.996$).

DISCUSSION AND CONCLUSIONS

This study's aim was to explore whether it is possible to implement a vignette-based assessment instrument for the competence of analysing the use of representations in the mathematics classroom, taking into account the role of different vignette formats. We were able to build on the work by Herbst et al. (2013): In comparison, the vignette formats included in this assessment instrument (text, comic, video) were very different, as, for instance, Herbst and colleagues had conserved the aspect of temporality across their vignette formats (video and animation formats). We thus consider our choice of vignette formats as relatively wide-spread within the spectrum of possible formats. The results indicate that despite this wide-spread choice of vignette formats, it is still possible to empirically reproduce a single competence dimension, and that in the case of the competence of analysing the use of representations, the analysis difficulty is not systematically determined by the vignette format. In particular, the pre-service teachers' competence of analysing was not connected with item design factors such as temporality, individuality of the persons shown or the context information that were implemented to different degrees in the three vignette formats. We have hence identified an empirically one-dimensional competence construct which is not dependent from the format of the vignettes used in the assessment instrument.

This finding can also be interpreted as supporting the validity of our instrument: The competence construct had been deduced from theory, the vignettes conceived

according to theoretical considerations related to analysis requirements, and the representations and the wording of the dialogues had been kept constant throughout the vignette formats even if the information provided in the vignettes varied with respect of other aspects as described above. These representations and the way they were dealt with might thus have been the core subject of analysis, as intended in the instrument's design.

Moreover, the test items' fit to a one-dimensional Rasch model without exception is a very positive finding also for further research: the competence of analysing the use of representations can not only be measured independently from the different vignette formats, but the results facilitate the investigation of factors that make the analysis of the use of representations difficult for teachers. As this study suggests that the vignette formats text, comic and video are comparably effective to assess pre-service teachers' competence of analysing the use of representations, further research focusing on this competence could explore design variations within only one of these formats.

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