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Teachers' noticing of language in mathematics classrooms

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Many studies point out teachers' crucial role in mathematics classrooms. This role is also emphasized through the increasing need of language-responsive teaching due to language diversity in the classrooms. The paper presents a qualitative study of teachers noticing mathematically relevant language issues in a video on a whole class discussion on variables. The study investigates which language resources and language obstacles the teachers notice and how they activate didactic categories of their content knowledge. It seems to be crucial to not only know the categories as disposition but also to activate them in a content-specific way.

Keywords: Pedagogical content knowledge, noticing, language-responsive teaching

Introduction

One important part of teachers' professional competence is their pedagogical content knowledge (PCK) (Shulman, 1986). Depaepe, Verschaffel, and Kelchtermans (2013) show that PCK has often been considered under perspectives of students' (mis)conceptions, instructional strategies, curriculum and others. Due to the increasing language diversity in mathematics classrooms, there is an increasing need of language-responsive teaching. However, only few studies deal with teachers' resources and obstacles when developing language-responsive mathematics classrooms (Radford & Barwell, 2016; Prediger, Sahin-Gür, & Zindel, 2018; Prediger, submitted). The aim of this study is to identify which language issues teachers notice in a classroom discussion and to analyze how they activate didactic categories when noticing these language issues. The article presents (1) the theoretical background of PCK and its role when noticing language issues, (2) the methods of the study, and (3) empirical insights which (mathematically relevant) language aspects teachers notice and how they activate didactic categories.

Background of the study

Identifying PCK in the connection from categories and practices

An important part of teacher knowledge is the pedagogical content knowledge (PCK) (for a literature review concerning different conceptualizations see Depaepe et al., 2013). In this context, Ball, Thames, and Phelps (2008) differentiate "knowledge of content and students" and "knowledge of content and teaching" (Ball, Thames, & Phelps, 2008, p. 399). They assume that "a clearer sense of ... content knowledge for teaching might inform the design of support materials for teachers as well as teacher education and professional development" (ibid., p. 405). This study aims at contributing to this clearer sense of content knowledge. Thereby, the study follows suggestions to focus not only the knowledge as dispositions but also on teacher practices (Depaepe et al., 2013) and the continuum from teachers' dispositions to performances in a situated perspective (Bloemeke, Gustafsson, & Shavelson, 2015). Our overarching project (Prediger, submitted; Prediger et al., 2018) is especially interested in the connections between teachers' (simulated) classroom practices and the knowledge

activated for these practices, following Bromme’s (2001) conceptualization. More precisely, this study deals with the categories teachers activate for noticing in language-responsive teaching.

Noticing as a relevant teacher practice in language-responsive teaching

In general, noticing is described as the process of making “sense of complex classroom environments in which they cannot be aware of or respond to everything that is occurring” (Jacobs, Lamb, & Philipp, 2010, p. 170). Noticing aspects consists of two processes: first “attending to particular events in an instructional setting” and second “making sense of events in an instructional setting” (Sherin et al., 2011, p. 5). Interpreting these events involves “relating observed events to abstract categories” (ibid., p. 5). Abstract didactic categories are the mental schemes that structure situations. This study defines these events or aspects as those utterances and actions that teachers could identify as language resources or language obstacles when activating abstract categories and relating them to learners’ specific utterances or actions (Figure 1). Hence, the aspects teachers notice depend on their background pedagogical content knowledge (Prediger & Zindel, 2017).

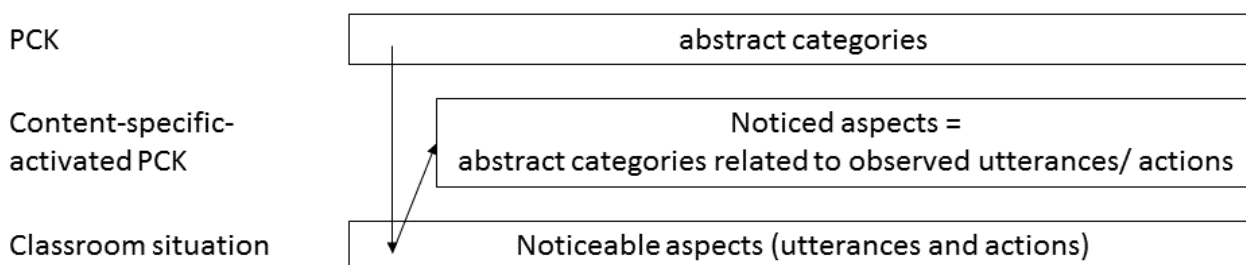


Figure 1: Noticing as activating PCK in a content-specific way

In the case of language-responsive mathematics teaching, *noticing language* has been identified as one of five typical situational demands (Prediger, submitted). Here, *noticing language* is the foundation for further jobs such as *supporting language* or *developing language*. With respect to the relevant categories, noticing language requires attending to learners’ obstacles, but even more on learners’ language resources in order to take decisions for an adaptive support. Other studies also focus on noticing the resources. Kilic et al. (2019) for example investigate the effects of a faculty-school collaboration program with regard to preservice teachers’ noticing of mathematical opportunities emerged from students’ mathematics.

For the case of language-responsive teaching, it is important that teachers know how the language issues are tied to the teaching of their subject (Bunch, 2013, p. 299). Hence, language-responsive teaching requires knowledge on mathematically relevant language demands and adequate teaching practices. In order to consider both, teachers’ knowledge and their practices, this study focuses on teachers’ processes in PD-integrated diagnostic activities.

This study focuses on two (abstract) didactic categories, which several studies highlight when dealing with language responsive teaching: *word* level and *discourse* level (Moschkovich, 2015; Prediger, submitted). Studies have shown that students’ obstacles and resources differ on these levels and that especially the discourse level is important for mathematics learning as language and mathematics are strongly connected on this level (Moschkovich, 2015).

Focus of the investigation

Based on these theoretical backgrounds, the aim of this study is to identify which language issues teachers notice in a classroom discussion and to analyze how they activate didactic categories when noticing these language issues. Hence, the research questions are:

(RQ1) *Which language resources and language obstacles do teachers notice when watching a video on a whole class discussion about the meaning of variables?*

(RQ2) *How do teachers activate the categories word level and discourse level when noticing these language obstacles and language resources?*

Methods

Data gathering: PD-integrated diagnostic activity

In the overarching project, we conducted several PD-integrated diagnostic activities due to two reasons. First, these activities offer insights in teachers' knowledge and second, the facilitator can directly react and use the results in the PD. In this paper, the focus is on diagnostic activities of *noticing language*. We collected $n=12$ written products on the diagnostic activity translated in Figure 2. The sample consisted of German middle and high school mathematics teachers in their third session of a volunteer professional development series on language-responsive mathematics classrooms. The transcript teachers should analyze after watching the video scene contains many different language resources and language obstacles (Figure 3, Figure 4). This richness allows analyzing which of these aspects teachers focus on and thereby teachers' noticing.

A grade 10 class worked on the following task and conducted a whole class discussion on the match:

Classroom task: Ms. Maier buys presents for her colleagues. One bottle of wine costs 3 Euro. Additionally, she needs one bag for 1 Euro. Does the function equation $f(x) = 3x + 1$ fit to this situation?

Activity for the teachers: Watch the video of the whole class discussion and analyze the corresponding transcript [here printed in Figure 4] with regard to the learners' conceptual and language resources and obstacles.

Figure 2: PD-integrated diagnostic activity on noticing language and identifying language issues

In order to identify potential starting points for learning processes, teachers should identify mathematically relevant language obstacles and mathematically relevant language resources. A coding scheme of content-specific language resources (R) and language obstacles (O) that teachers could notice in this scene (Figure 3, Figure 4) was developed by, and discussed within, our research group. There is no hierarchy in the list. This list is not a complete list, so the coding scheme allows for additional individual categories (R9 and O7). Each noticeable aspect contains an (abstract) category (here: the discourse level/ different discourse practices) related to the observed event (i.e. utterance and/or action; Figure 1). After watching the video scene of the classroom discussion in the PD, the teachers should analyze the transcript with regard to conceptual and language obstacles and resources. We collected teachers' written products on this task and videotaped the whole PD including the group discussions in order to gain insights in the PD-processes.

- (R1) Differentiating the amount of colleagues and the amount of bottles
- (R2) Explaining the meaning of x as number of bottles/colleagues
- (R3) Explaining the meaning of the constant “3” as price of one bottle and the meaning of “1” as price of one bag
- (R4) Generalizing the number of bottles/ colleagues
- (R5) Describing a general relationship between the number of colleagues/bottles and the price by calculating values
- (R6) Generalizing the number of bags
- (R7) Describing a general relationship (between any amount of bottles/colleagues/bags/prices)
- (R8) Explaining the meaning of variables as unknowns and generalizers
- (R9) Further resource
- (O1) No identifying the meaning of “1” as price of one bag
- (O2) No generalization of the amount of colleagues/bottles
- (O3) No explanation of the meaning of $f(x)$ as total price
- (O4) Inappropriate basis for argumentation when explaining the (non)match of the function equation
- (O5) Overstressing the relevance of “colleagues” as singular or plural (A/N: both have the same spelling in German)
- (O6) No explication of the functional relationship between the number of colleagues/bottles and the price
- (O7) Further obstacle

Figure 3: Coding scheme for noticeable aspects (utterances and actions) in the scene

2	David	Hm, Ms. Maier buys [...] presents for her colleagues. One bottle of wine costs 3 Euro. Additionally, she needs one bag for 1 Euro.	
3	Max	[5s] For?	O1
5	Celina	Well, I don't think that fits, because hm I think (...) f(x) equals 3 plus 1...	O2, O4
6	Fynn	I don't think that fits either, because it doesn't say how many bottles she buys (...)	R1 O2
7	Alexandra	I think that fits, because the function equation has 3x plus one. And three is then (...) the value of the bottles, x are the colleagues. And plus 1 is what you only have to pay once, because the 3 are always with the colleagues (...)	R2, R3, O3
9	Altin	Hm. I think that fits, because hm x is simply intended for the colleagues. So, if she had three colleagues, she would have to pay nine Euros.	R4, R5
10	Nils	[3s] It depends on hm whether she buys more than one bottle of wine. Because, if more bottles were bought, you could take the amount as x and then the question fits.	R2, R4
11	Tatjana	Well I think it doesn't fit because the number of colleagues is unknown.	O4
12	Ben	I think, it also doesn't fit because the text says colleagues. And these are several and our function equation says 3x (...)	O4, O5
13	Chris-tian	And if 3x, so the number of bottles is unknown, then you don't know how many bags you need either. Then this should be x, too. You don't know how many bags she takes.	R6, R7, O6
17	Fynn	Well this does not fit because it is not given how many bottles the woman wants to buy.	O4
19	Max	It doesn't fit because the number [...] is not given, how many – for how many colleagues she needs how many bottles. Because it needs to be better [...] explained or presented.	R1, R7
21	Nils	It fits because the number of colleagues is x. It is a non-determined number. That means, you can choose the number, how many colleagues there are.	R8
22	Alexandra	Well it says that the wine costs three Euro. And three is three times x and x is the unknown. That means that this is the number of colleagues. And it says she needs <u>one</u> bag. So she only buys one bag and therefor plus 1.	R2, R3, O3
24	Altin	The problem is, how big is the bag? Because [...] if there are more colleagues, then I don't think that all bottles fit into one bag and then she has to buy a second one. And	R6, R7
-			
26		then there would have to be plus two.	

Figure 4: Transcript of the discussion and noticeable language resources (R) and obstacles (O)

Data analysis procedures

This paper focuses on the results of teachers' written analysis of the classroom discussion. These written products of the teachers were analyzed by collecting the noticed language aspects and comparing them with the aspects R1-R9 and O1-O7 (Figure 3 shows the inductively generated coding scheme for noticeable aspects). As teachers do not make the distinction of resource and obstacle explicit in their products, also utterances or aspects that *could* be used as a resource are coded as noticed resource (This reflects a resource-oriented positioning towards teachers' products.) Following the conceptualization of "noticed aspects" as "abstract categories related to specific utterances or actions" (Figure 1), teachers' written products were also analyzed with regard to the question *how* they activate the (abstract) categories *word level* and *discourse level* and especially whether they activate them in a content-specific way.

Results

Insights into three cases

In a first approach, the paper presents three cases of teachers' written products (Figure 5) in order to illustrate the functioning of the coding scheme (language-related aspects are highlighted in black).

<p>Camilla Lippott</p> <ul style="list-style-type: none"> - Meaning of $f(x)$ and x is not clear for many learners, as well as the meaning of the 1 - changing meaning of $x \rightarrow$ number of colleagues; number of bags - David: only reads aloud, does not participate in the discussion (O7) - Max: does not recognize the meaning of the variable - Alexandra seems to have understood the assignment, but has difficulties in verbalizing (O7) - Celina does not give reasons at all (O4) 					
<p>Selma Ludwig</p> <table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: left; border-bottom: 1px solid black;"><u>Mathematical resources & difficulties</u></th> <th style="text-align: left; border-bottom: 1px solid black;"><u>Language resources & difficulties</u></th> </tr> </thead> <tbody> <tr> <td style="vertical-align: top;"> <ul style="list-style-type: none"> • Meaning of the variable x not clear (Fynn, Max, Celina) • Notion of variable not clear • Additional variable for bags (Altin, Christian) </td> <td style="vertical-align: top;"> <ul style="list-style-type: none"> • Colleagues $\neq 3x$? (O7) • Meaning of "Does the function equation fit?" not clear (O7) • <u>One bag</u> (O1) • Explanation linguistically vague (Alexandra) (O7) • Number of colleagues \neq Colleagues (O5) </td> </tr> </tbody> </table>		<u>Mathematical resources & difficulties</u>	<u>Language resources & difficulties</u>	<ul style="list-style-type: none"> • Meaning of the variable x not clear (Fynn, Max, Celina) • Notion of variable not clear • Additional variable for bags (Altin, Christian) 	<ul style="list-style-type: none"> • Colleagues $\neq 3x$? (O7) • Meaning of "Does the function equation fit?" not clear (O7) • <u>One bag</u> (O1) • Explanation linguistically vague (Alexandra) (O7) • Number of colleagues \neq Colleagues (O5)
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<ul style="list-style-type: none"> • Meaning of the variable x not clear (Fynn, Max, Celina) • Notion of variable not clear • Additional variable for bags (Altin, Christian) 	<ul style="list-style-type: none"> • Colleagues $\neq 3x$? (O7) • Meaning of "Does the function equation fit?" not clear (O7) • <u>One bag</u> (O1) • Explanation linguistically vague (Alexandra) (O7) • Number of colleagues \neq Colleagues (O5) 				
<p>Peter Tremnitz</p> <ul style="list-style-type: none"> - Max for? unknown (by, for) (O1) - Celina creates a model on her own (and in a wrong way) instead of analyzing the given term - Fynn struggles with interpreting the x as variable - Alexandra has understood the problem, but she can only insufficiently verbalize the meaning of the 1 (for one bag) \rightarrow clarifies it later (O6) - Tatjana does not find a concrete number of colleagues – obstacle in functional relationship - Ben: $3x$ – not interpreted variable - Christian: it remains unclear whether he imposes an upper limit for one bag or whether he regards the number of bags as proportionally increasing. The task says that she needs only one bag. (R6, R7) 					

Figure 5: Three cases of teachers' written products and their coding

Camilla points out that David only reads aloud and does not participate in the discussion (O7). Hence, she activates the category discourse level in terms of participating in the classroom discourse. Besides, she states that Alexandra struggles with verbalizing the functional relationship (O7). Thereby, she names the discourse practice of verbalizing, but she does not explicitly relate it to the observed utterance. It remains unclear which difficulties Alexandra might have and whether these are difficulties in finding correct words on a lexical level or whether she has difficulties in explaining on the discourse level for example. A similar category could underlie her observation that Celina does not give any reasons at all (resp. inappropriate basis for argumentation, O4).

In contrast to the two other teachers, Selma makes an explicit distinction between mathematical aspects and language aspects. She identifies five language obstacles: O1, O5 and three further obstacles that are summarized under O7. The further obstacles are (1) identifying the meaning of "3x" as number of colleagues, (2) no understanding of the question, and (3) explanation linguistically vague. Thereby, Selma activates the category "discourse level", too. However, she describes the aspects only partly by only naming the abstract category ("explanation vague") or by only naming a part of the situation ("one bag"). It remains unclear which categories she relates to which observed utterances.

Peter recognizes the possible idea of generalizing the number of bags R6 as “proportionally increasing” (R7). Thereby, he notices an utterance that could be used as a resource for the discursive demand of generalizing and describing a general relationship, even though this is not the relationship focused by the task. Peter activated the category “discourse level”, too, by explicitly relating the discourse practices to the observed utterances in most cases.

Whereas Camilla and Selma only notice obstacles, Peter also identifies a potential resource, although he does not make explicit that it is a resource. Nevertheless, noticing such aspects is presumably a first step towards responding to those utterances in an appreciative way.

Teachers’ noticing of language resources and language obstacles

Figure 6 presents a summary of the coding of all twelve teachers’ products with regard to the amount of noticed resources and noticed obstacles, sorted by teachers (Figure 6, left) and sorted by aspects (Figure 6, right).

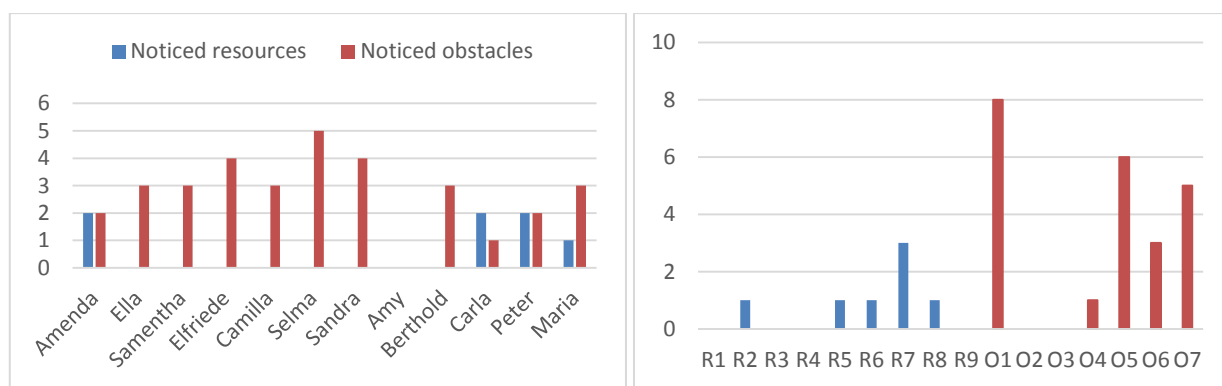


Figure 6: Amount of noticed resources and noticed obstacles by teacher (left) and by aspect (right)

It is striking that teachers notice much more obstacles than resources (Figure 6). Only four teachers notice resources at all, but even these four teachers notice only one or two utterances that could be used as resources in the whole scene (Figure 6, left). These observations raise the question, why teachers notice some aspects very often, whereas other aspects are not noticed at all. In order to identify possible reasons for these observations, the following section investigates teachers’ underlying categories in their noticing.

Teachers’ activated categories in their noticing of language obstacles and resources

As teachers focus much on the aspects O1 and O5 (Figure 3), they seem to focus on demands on a *word level*. This problem is already well known (Moschkovich, 2015; Prediger et al., 2018). Both aspects describe obstacles that result from wrongly understood words in the text. For noticing other aspects it would have been necessary to activate further categories like other discourse practices on the discourse level and relating them to learners’ utterances.

In the three presented cases, all teachers activate the category *discourse level*, although they do this on different ways. Some teachers remain on the discourse level in a general way (like Camilla), others differentiate several discourse practices (but name only the category or only the utterance like Selma) and others differentiate discourse practices and relate them explicitly to the observed utterances or actions (like Peter). The same phenomena become visible in other cases, too. These

observations are paralleled by the fact that some teachers differentiate single students whereas other teachers describe to resources and obstacles of the class as a whole.

Summing up, teachers focus much more on language obstacles than on language resources. If they identify language resources, they remain on the word level. Only few teachers notice different discourse practices that could be built on although there are many different noticeable discourse practices in the scene that could be used as a resource in a further classroom discussion (Figure 3, Figure 4). If activated at all, the categories on the discourse level are often activated in a general way, i.e. that the abstract categories are not explicitly related to the observed utterances or actions.

Discussion and outlook

Noticing aspects consists of two processes, “attending to particular events” and “making sense of events” (Sherin et al., 2011, p. 5). For the case of language-responsive teaching, this paper has investigated which aspects teacher notice and how they activate the in this case important didactic categories *word level* and *discourse level* (concerning the two categories cf. Moschkovich, 2015; Prediger, submitted). The results show that teachers focus much more on language obstacles than on language resources. Such a deficit-oriented focus presumably leads to unused learning opportunities, as the existing resources are not identified as possible starting points for learning processes.

Teachers’ noticing depends on teachers’ background knowledge of didactic categories (Prediger & Zindel, 2017). However, it seems to be not enough to know the categories as teachers remain very vague in their articulation of the noticing. So knowing a category seems to be only a first step in a category-based noticing. A further step is activating a category in a content-specific way, i.e. not only naming the abstract category, but also relating it to the observed mathematical issue (cf. Figure 1). It might be helpful if PDs dealt with possible language resources and language obstacles that could be expected in different math contents. Hence, PDs should support teachers in acquiring didactic categories as well as activating them in a content-specific way in order to support teachers’ noticing.

Of course, the results gained by a sample of $n=12$ must be interpreted cautiously. We continue the data gathering in following PDs, so that this sample will be enlarged. Furthermore, we are going to analyze how this first noticing develops in group-discussions in the PDs. We will analyze the video material of the PD in order to gain deeper insights in teachers’ noticing and its development.

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