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# What language demands count in subject-matter classrooms?

# A study on mathematics teachers' language-related orientations and diagnostic categories for students' explanations

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Abstract

To overcome language challenges in subject-matter school achievement, mainstream teachers of all subjects are requested to foster students' academic language proficiency in subject-matter classrooms without being systematically prepared for this job, for instance, for the question what kind of language demands count as relevant in their classroom. The study investigates how 223 secondary mathematics teachers analyze students' written explanations in a diagnostic activity aimed at unpacking the language demands they identify as relevant. The study reveals that teachers activate a large variety of different diagnostic categories, and many teachers focus on language demands that are too peripheral to subject-matter learning. These teachers' unproductive focus seems to be connected to their language-related orientations, which were captured in a questionnaire. The statistical analysis of the data shows some language-related orientations are significantly connected to the activation of more suitable categories. Thus, which language demands teachers notice and value in students' mathematical explanations seems to influence whether they assume responsibility for language learning. Consequences for professional development are discussed.

Keywords

Language in subject-matter classrooms, teachers' orientations, teachers' noticing, identifying language demands

For more than 30 years, researchers in second language education (Cummins, 1986) and subject-matter education (Secada, 1992) have identified academic language as a key to subject-matter achievement: Multilingual and monolingual students from underprivileged background with limited access to academic language (in the following referred to as "language learners") perform lower in higher-order thinking skills than their more language-proficient peers (Cummins, 1986). Hence, fostering academic language learning in subject-matter mainstream classrooms is crucial for increasing equity and is therefore often requested, for example, in the Common Core States Standards in the US (CCSS, 2010) or by the Council of Europe (e.g., Thürmann, Vollmer, & Pieper, 2010).

However, many researchers have emphasized that most subject-matter teachers are not yet prepared for fostering students' language learning in subject-matter mainstream classrooms (Adler, 1995; den Brok, van Eerde, & Hajer, 2010; Moschkovich, 2010; Lucas & Grinberg, 2008; Hajer, 2006; Haworth, 2008). Whereas some researchers find it a problem that many teachers do not assume responsibility for language as a learning goal in their subject-matter classroom (Lucas & Grinberg, 2008; Adler, 1995), others empha-

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size that the general construct of language must be refined into those language demands that are crucial for the subject matter to be learned (Bunch, 2013; Turner et al., 2019). Making these distinctions is particularly important since case studies have revealed that non-language-specialist teachers (such as mathematics teachers) often seem to focus on language demands that are not in the core for the subject-matter learning (Turner et al., 2019; Prediger, 2019).

Although these case studies have provided first insights into teachers' language-related orientations, research surveys have called for extending the studies to larger samples of subject-matter teachers (den Brok et al., 2010). Additionally, the connections between the identified language demands and their language-related orientations in teachers' thinking have not yet been explored.

The current study intends to reduce these research gaps by investigating the orientations and diagnostic categories of 223 mathematics teachers: By capturing how teachers analyze students' written explanations for a mathematical concept, the study uses a standardized questionnaire to explore the range of teachers' diagnostic categories and shows how they are connected to the language-related orientations they express. In this way, the study can contribute to specifying how to work with teachers' starting points in professional development programs on language-responsive teaching for subject-matter teachers.

The first section presents the theoretical framework for the constructs of orientations and diagnostic categories for fostering language learning in subject-matter classrooms, and the second section presents the methods of the study. The third section reveals empirical results, and the fourth section discusses their consequences for professional development.

# 1 Theoretical background: Subject-matter teachers' language-related orientations and noticing categories

## *1.1 Teachers' language-related orientations and categories as components of teacher expertise*

In line with Grossman, Smagorinsky, and Valencia's (1999) activity theoretical approach, teacher expertise can be characterized by teachers' practices for mastering typical, socially constructed situational demands and by the practical and conceptual tools the teachers activate in their practices. According to Bromme (1992, 2001), these conceptual tools can be further characterized as categories, in other words, as conceptual, non-propositional knowledge elements that filter and focus the categorial perception and the thinking of the teacher when coping with situational demands.

A further component of teacher expertise that strongly influences the teachers' practices is orientations (Bromme, 1992; Schoenfeld, 2010). In line with Schoenfeld (2010, p. 29), we define orientations as the "content-related and more general beliefs that implicitly or explicitly guide the teachers' perceptions (e.g., beliefs about the content or students' learning processes)" (Prediger, 2019, p. 370).

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Thus, in the approach of this paper, teachers' expertise is conceptualized by (a) the practices by which they cope with recurrent situational demands, (b) the personal categories they use for focusing their perception and thinking, and (c) the orientations which underlie teachers' practices. As earlier studies show (Prediger, 2019), this conceptualization allows the specification of relevant aspects of teacher expertise for a specific topic (such as in this paper, language-responsive subject-matter teaching) by conducting a "job analysis" (Bass & Ball, 2004). This is presented in the following section for the topic of language-responsive teaching.

### *1.2 Language-related orientations for fostering language learning in subject-matter classrooms*

Several qualitative research studies have identified the recurrent situational demands for subject-matter teachers in language-responsive mainstream classrooms (Hajer & Norén, 2017; Lucas & Villegas, 2013; Grossman et al., 1999; Smit, Bakker, van Eerde, & Kuijpers, 2016; den Brok et al., 2010; Bunch, 2013; synthesized in Prediger, 2019). The different approaches agree that fostering language learning goes beyond isolated vocabulary work: Its main focus is engaging students in rich discourse practices such as explaining and arguing (Snow & Uccelli, 2009; Smit et al., 2016; Moschkovich, 2013, 2015), as the construct of discourse practice links the mental processes with classroom discussions (Moschkovich, 2015; Erath et al., 2018; similar in other theoretical frameworks: discourse functions, e.g., Thürmann et al., 2010). For teachers, this means that typical situational demands comprise demanding and supporting students' language production and developing students' language with a longer-term perspective in view. However, two situational demands turned out to be even more basic, therefore influencing these three demands (Turner et al., 2019; Hajer, 2006):

- Identifying mathematically relevant language demands so that the noticing and supporting can focus on crucial rather than peripheral demands
- Noticing and evaluating language resources and further learning needs in students' utterances and written products (e.g., with pedagogical tools for formative assessment)

For these reasons, the current study focusses on these situational demands in an activity setting involving evaluating students' written explanations.

In general, teachers' beliefs have been shown to have a heavy impact on language teaching (Haworth, 2008; Briggs, Dearden, & Macaro, 2018). Here, we follow Schoenfeld (2010) in using the construct of orientations rather than beliefs in order to account for the internal subjective rationalities. Beyond some very general orientations (e.g., socio-constructivist orientations about learning or accepting multilingual realities), five language-related orientations have been identified in many qualitative case studies as positively influencing teachers' practices in mastering the above jobs:

- **O1: Language as a learning goal in subject-matter classrooms.** Teachers vary in the extent to which they assume responsibility for language as a learning goal in their subject-matter classrooms (Adler, 1995; Banegas, 2012; Byrnes, Kiger, & Manning,

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1997; Haworth, 2008; Lucas & Villegas, 2013; Lyon, 2013; McLeman, Fernandes, & McNulty, 2012).

- **O2: Striving for pushing rather than reducing language.** Whereas some teachers tend to react to diverse language proficiencies by constantly reducing language demands (Lyon, 2013), researchers have emphasized that language production should be pushed in order to enable students' language development with language demands in the zone of their proximal development (Moschkovich, 2013). Teachers striving for pushing language have been shown to take more effective actions than language reducers (Lyon, 2013).
- **O3: Focus on the discourse level rather than on word level only.** Many teachers have been shown to act only on the word level of teaching new vocabulary (Turner et al., 2019; Schleppegrell, 2007; Bunch, 2013). Others have already realized that involving students in rich discourse practices such as explaining and arguing is more relevant for the integration of language and content learning (see above; Moschkovich, 2015; Zahner et al., 2012).
- **O4: Integrative perspectives instead of additives only.** Some teachers consider language learning to be something additional in mathematics classrooms. Other teachers already hold the general orientation that content and language learning can be integrated in order to reach mathematical content goals (Banegas, 2012; Moschkovich, 2015; Schleppegrell, 2007; Smit & van Eerde, 2011), starting from identifying the language demands in concrete mathematical learning situations. Teacher practices based on this orientation were shown to act in a more goal-oriented, functional way in qualitative studies (Zahner et al., 2012).
- **O5: Conceptual understanding before procedures.** The language gap mainly occurs for higher order thinking skills (Cummins, 1986). In mathematics, this refers to conceptual understanding in particular (Prediger, Wilhelm, Büchter, Gürsoy, & Benholz, 2018). However, while many teachers of language learners restrict their learning opportunities to procedural knowledge (Adler, 1995; Prediger, 2019), other teachers focus on developing conceptual understanding as a core orientation for language-responsive classrooms in order to provide access to success in mathematics (Zahner et al., 2012).

Beyond the multiple qualitative insights into the various ways these five orientations are relevant, no quantitative data exists yet on how strongly these orientations are involved in the way teachers actually observe and notice content and/or language issues in students' utterances.

### *1.3 Language-related diagnostic categories for identifying language while noticing students' explanations*

As Sherin and van Es (2005) have argued, teachers' classroom practices rely heavily on what they notice in classroom complexity. Hence, teachers' diagnostic practices are suitable first practices to be investigated in capturing teachers' expertise. Morris et al. (2009) show that unpacking the sub-goals of a task is an important part of teachers'

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diagnostic practice. In the context of language-responsive teaching, these sub-goals correspond to the language demands that teachers consider relevant.

Within the chosen conceptualization of teacher expertise (see Section 1.1; following Bromme, 1992), investigating teachers' diagnostic practices calls for identifying the personal categories that teachers activate to notice and evaluate students' products. This includes the mathematical sub-goals and language aspects that a teacher considers relevant.

Earlier qualitative case studies have provided some first indications that many teachers only activate language aspects on the word level (technical terms and vocabulary) but do not yet focus on the discourse by categories such as discourse practice of explaining meanings (Moschkovich, 2015). However, if they activate the discourse practices category in order to distinguish students' utterances, they seem to be able to provide mathematically relevant language support (Prediger, 2019). Other case studies problematize the finding that many teachers' focus on surface categories of language such as grammar or orthography without taking into account discourse practices as a category of thinking (Adler, 1995; den Brok et al., 2010).

In their case studies on pre-service teachers, Turner et al. (2019) distinguish three perspectives to which teachers' personal categories can belong: From a lexicon perspective, only personal categories on the word level and technical terms are addressed. From a register perspective, the lexicon perspective is enriched also by categories of grammar. Only from a socio-cultural perspective can teachers also activate categories on the discourse level such as distinguishing different discourse practices.

## *1.4 Research questions*

Existing qualitative studies on subject-matter teachers' thinking about language in classrooms have identified potential orientations and personal categories that seem to influence teachers' practices in supporting language learners in mainstream classrooms (Hajer, 2006; den Brok et al., 2010; Turner et al., 2019; Prediger, 2019). However, these studies have focused only on small groups of teachers and have not yet been extended to larger sample sizes. Thus, the hypothesized connections between selected orientations and categories chosen in diagnostic situations have not yet been investigated systematically. Therefore, the current study pursues the following research questions:

(Q1) What language-related orientations do mathematics teachers hold and how do the orientations correlate with each other?

(Q2) What personal diagnostic categories do teachers activate when noticing and evaluating students' written explanations of a mathematical concept?

(Q3) How are the language-related orientations and the personal diagnostic categories connected to each other?

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# 2 Methods

## *2.1 Methods of data gathering*

**Sample.** The sample in the current study consisted of German mathematics teachers of lower and upper secondary schools (*n* = 223) in their first session of a volunteer professional development course on language-responsive mathematics classrooms. The teachers had between 2 and 30 years of experience in math teaching (median 8 years) and 0-20 hours of previous encounters with ideas about language-responsive classrooms, mainly without reference to mathematics (median 6 hours).

**Questionnaire for language-related orientations.** Teachers' orientations were captured by a standardized questionnaire with five scales, each consisting of four items with six-point Likert scales (1 = *strongly disagree*, 6 = *strongly agree*):

- **O1 Goal: Language as a learning goal in the subject-matter classroom**, e.g., "Language prerequisites should be assured in language classes, not in mathematics classes" (with reversed polarity).
- **O2 Push: Striving for pushing instead of reducing language**, e.g., "As my class has language difficulties, I constantly challenge them with respect to language."
- **O3 Discourse: Focus on the discourse level, not only on the word level,** e.g., "For students with low language proficiency, I pay more attention to describing, explaining, and arguing than to specific technical terms."
- **O4 Integrative: Integrative perspectives instead of additive,** e.g., "With the use of language support, learners can better achieve content-learning goals."
- **O5 Concept: Conceptual understanding before procedures,** e.g., "Only mathematical high achievers can develop conceptual understanding; this is the icing on the cake."

All scales for **O1** to **O5** were analyzed with respect to internal consistency, and all but one scale reached acceptable values for Cronbach's alpha: **O1**: $\alpha = 0.674$, **O3**: $\alpha = 0.593$, **O4**: $\alpha = 0.485$, **O5**: $\alpha = 0.618$. Scale **O2** was reduced to one item due to its insufficient consistency of $\alpha = 0.268$.

**Open category-eliciting activity.** To capture teachers' personal diagnostic categories in their full diversity and range, open-ended category-eliciting diagnostic activities have proven to be more suitable than multiple-choice items (Kelly, 1955; Bromme, 1992) in gaining explorative insights into teachers' perceptions and thinking. In a preliminary study (Prediger, Şahin-Gür, & Zindel, 2018a), the open-ended diagnostic activity in Figure 1 was developed: Following the variation principle for eliciting personal categories (Kelly, 1955), diagnostic judgments were requested for three contrasting student explanations. The focus was on students' written explanations of a mathematical concept, because explaining meanings of concepts has been identified as the most important dis-

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course practice in mathematics classrooms, especially for language learners (Moschkovich, 2010; Zahner et al., 2012). Teachers were asked to name their criteria, evaluate the three texts according to them, and justify their evaluation.

**Diagnostic Activity**

The Grade 8 class has introduced the meaning and the formula for the slope of linear functions.
The homework task (formulated as on the right) requested students to write summaries.

Explain what $m = \frac{y_2-y_1}{x_2-x_1}$ means and what you can describe with it.

Analyze the three students' texts using four self-defined categories, two for mathematical aspects and two for language aspects. Evaluate using 0,1, or 2 points and justify your decisions.

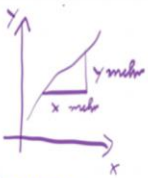
| Ali | Suleika | Tom |
|---|---|---|
| You want to calculate the slope. First you chose two points, e.g. x=3, y=1 and x=5, y=8. Second, you evaluate: $m = \frac{8-1}{7-3} = \frac{7}{2}$. Ready | The slope saying, how much growing the function per x-step. Thus, how much get y more per how much get x more. The PER makes the DIVIDED.  | Iff yu for exempel have y=0.2+10 of the mobile phone tarif. For exempel at 10 minutes it is 12 €, at 30 minutes it is 16 €. Thus, distance 20, price more 4 € and than $\frac{4\,€}{20\,min} = \frac{0.2\,€}{1\,min}$. Thenn, costs per minute my price 0.20 € more costly. |

**Fig. 1. Diagnostic activity for teachers** (translated from German with students' errors preserved)

The exemplary mathematical topic for students' written explanations, the slope of linear functions, has two mathematical sub-goals: (1) procedural knowledge when evaluating the slope formula for specific values and (2) conceptual knowledge of its overall meaning (the slope captures the growth of a function) and of the meaning of its components (the quotient mathematizes the ratio of two distances). This type of diagnostic activity can elicit different personal categories for different mathematical sub-goals.

With respect to the language demands, the students' texts were chosen to show a wide spectrum of language features on the surface level (e.g., orthography), word level (technical terms), sentence level (grammatical structures), and discourse level (four discourse practices can be distinguished here: reporting procedures, explaining meanings, general phrasings, and concrete phrasings; for example, Suleika explains meanings in a general way, whereas Ali reports procedures concretely). The research reported in this article investigates which of these features are targeted in teachers' personal categories.

## *2.2 Data analysis procedures*

For research question Q2, the manifold personal criteria that teachers stated for the category-eliciting activity in Figure 1 were analyzed using a specifically developed categorial scheme. The first version of the categorial scheme was deductively derived from the current state of research and then inductively adapted to the data in order to capture all personal criteria (Prediger et al., 2018a). As the teachers used the same words for criteria with different individual meanings, the verbatim criteria and their assessment scores for each student text also had to be taken into account for the categorization.

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**Table 1.** Examples of diagnostic-product evaluations and elicited criteria of two teachers

| | Mathematical Criterion A | Mathematical Criterion B | Language Criterion A | Language Criterion B |
|---|---|---|---|---|
| **Teacher Paula** | **021** "dependency of variables" (→ *conceptual knowledge*) | **201** "explanation of the procedure (recipe)" (→ *procedural knowledge, reporting procedure*) | **110** "sentence construction" (→ *grammar, mode of expression, surface level*) | **120** "uses technical words" (→ *technical terms, surface level*) |
| **Teacher Hamid** | **222** "explains the difference: y2-y1, x2-x1" (→ *conceptual knowledge, explaining meaning*) | **222** "Quotient explained" (→ *conceptual knowledge, explaining meaning*) | **220** "slope" (→ *technical terms, surface level*) | **120** "general statement → math criterion?" (→ *general phrasing*) |
| **Teacher Jane** | **221** "recognizes that the expression is the slope" (→ *procedural knowledge, technical terms*) | **021** "correctly explains the slope (as basic knowledge)" (→ *conceptual knowledge, explaining meaning*) | **020** "explains in general (not with example)" (→ *general phrasing*) | **110** "grammar/orthography" (→ *surface level, orthography & grammar*) |

(**021** refers to assessment scores for Ali, 2; Suleika, 0; and Tom, 1; *italics* denote categories assigned by researcher)

Table 1 provides examples of three teachers' noticing: Their different assessment scores show that they evaluated the students' explanations differently, based on different underlying personal constructs. Some teachers' criteria were categorized under more than one category when their criteria itself or in combination with their assessment scores addressed several aspects. These personal criteria varied between very vague aspects such as mode of expression and core categories on the discourse level. It should be noted that criteria on the discourse level (general/concrete phrasing, explaining meanings/reporting procedures) can appear as language criteria or mathematical criteria. The complete categorial scheme will be shown in Table 4. The categorization procedures reached inter-rater reliabilities between Kappa = 0.97 and 1.00. The frequencies of category use were determined.

For research question Q1, the questionnaire data on teachers' language-related orientations was analyzed descriptively with respect to means and standard deviations as well as the correlation between the orientation scales (using Pearson's correlation coefficient *r*). Within each scale, sub-samples were formed according to agreement: Teachers with average agreement values ≤ 4 were put in the lower group. e.g., language reducer in **O2-** and > 4 in the higher group, e.g., language pusher in **O2+**).

For research question Q3, frequencies of category use were compared for sub-samples formed according to the language-related orientation scales **O1-O5**. Fifty hypotheses on group differences were tested using *t*-tests on a 5% level of significance for 10 categories and five pairs of sub-samples. Effect size *d* was calculated by relating the mean differences of sub-samples to the standard deviation (Cohen's *d*).

# 3 Results

## *3.1 Teachers' language-related orientations*

Research question Q1 asks about the language-related orientations that teachers hold. Table 2 lists the descriptive results for the orientation scales and Table 3 shows their correlation to each other.

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The results in Table 2 show that there is an above-average level of awareness in this sample for all five orientations, in particular orientations **O1** and **O4**. This also explains the distribution among the subgroups: For four orientations, the majority of teachers are in the intended higher group, so that the language-related orientations are in principle productive, even if there is still a shift necessary from reducing language towards pushing (**O2**).

**Table 2:** Teachers' language-related orientations: Descriptive results

| | Mean | Size of Subsamples | |
|---|---|---|---|
| | m (SD) | **O-** (Score ≤ 4) | **O+** (Score > 4) |
| **O1 Goal**: Language as a learning goal | 5.10 (0.73) | 23 (10%) | 200 (90%) |
| **O2 Push**: Striving for pushing instead of reducing language | 4.35 (1.21) | 112 (50%) | 106 (48%) |
| **O3 Discourse**: Focus on discourse, not only | 4.29 (0.86) | 87 (39%) | 136 (61%) |
| **O4 Integrative**: Integrative instead of additive | 4.98 (0.66) | 28 (13%) | 195 (87%) |
| **O5 Concept**: Conceptual understanding before procedures | 4.52 (0.86) | 68 (30%) | 155 (70%) |

Table 3 shows the correlations between the five orientation scales. It is interesting that **O2** and **O5** do not correlate, i.e., language reducers can also prioritize conceptual understanding and vice versa. The highest correlation, at 0.58, is between **O1** and **O4**: Those who assume responsibility for language as a learning goal also see language as an integral instead of additive part in the mathematics curriculum. The correlations between these orientations raise the question of how they are connected to teachers' noticing practices.

**Table 3:** Correlation between scales of teachers' language-related orientations

| | O1 Goal | O2 Push | O3 Discourse | O4 Integrative | O5 Concept |
|---|---|---|---|---|---|
| **O1 Goal**: Language as a learning goal | 1 | | | | |
| **O2 Push**: Striving for pushing instead of reducing language | 0.39 | 1 | | | |
| **O3 Discourse**: Focus on discourse, not only | 0.34 | 0.42 | 1 | | |
| **O4 Integrative**: Integrative instead of additive | 0.58 | 0.25 | 0.19 | 1 | |
| **O5 Concept**: Conceptual understanding before procedures | 0.38 | 0.06 | 0.23 | 0.29 | 1 |

## *3.2 Range of teachers' personal diagnostic categories*

In pursuit of research question Q2 (activated personal diagnostic categories), the first column of Table 4 shows all personal diagnostic categories that could be identified in the teachers' criteria in the research sample. In their focus on mathematical criteria, conceptual and procedural knowledge were distinguished by nearly all teachers (further criteria, for example, dealing with graphical representations, are not listed here).

In their language-related criteria, only 29% of the teachers referred to the word level by checking for technical terms. 79% of the teachers focused on categories that are situated only on the surface level, for example, addressing orthography (30%) or aspects of grammar (48%). These categories belong to what Turner et al. (2019) classified as a register perspective.

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**Table 4**. Frequencies of personal diagnostic categories used for evaluating students' written explanations and significant differences between sub-samples built with respect to orientations

| Teachers' categories with different focuses | Frequency of category use in whole sample ($n$ = 223) | Group differences significant with respect to | | | | |
|---|---|---|---|---|---|---|
| | | O1-\|+ Goal | O2-\|+ Push | O3-\|+ Discourse | O4-\|+ Integrative | O5-\|+ Concept |
| *Focus on mathematical criteria* | | | | | | |
| Conceptual knowledge | 91% | | | | | |
| Procedural knowledge | 55% | | | | | |
| *Focus on discourse level (language or math criteria)* | 73% | | | | | |
| Concrete, example-bound phrasing | 25% | | | | | |
| General phrasing | 25% | * | | | | |
| Explaining meaning | 47% | | ** | | | |
| Reporting procedure | 19% | | | | | |
| *Focus on discourse level (only language criteria)* | 14% | ** | * | | * | |
| Concrete, example-bound phrasing | 7% | ** | | | ** | |
| General phrasing | 7% | ** | | | ** | |
| Explaining meaning | 6% | ** | | | ** | ** |
| Reporting procedure | 4% | ** | | | | ** |
| *Focus on language beneath discourse level* | | | | | | |
| Surface level | 79% | | | | | |
| Orthography | 30% | | | | | |
| Grammar | 48% | | | | | |
| *Word level:* Technical terms | 29% | | | | | |
| *Vague criteria* | 41% | | | * | | |
| Understandability | 35% | | | | | * |
| Mathematical correctness | 11% | | | | | |
| Mode of expression | 15% | | | | * | |

Differences between subsamples that are significant in $t$-test are marked with * for $p < .05$ and ** for $p < .01$.

Beyond the register perspective, 42% of the teachers addressed vague categories such as understandability (35%), mathematical correctness (11%), and mode of expression (15%). Although these categories are not yet explicit and concise, they carry a germ of a comprehensive language view, namely a potential focus on language-content interaction.

Within our sample, only 14% of the teachers articulated a language-related criterion that belongs to categories on the discourse level, for example, different discourse practices such as explaining meanings (4-7%). In contrast, 73% of the teachers considered any discourse practices to be among the joint set of mathematical and language-related criteria. Thus, discourse practices are considered mathematically important but not yet understood as a relevant language demand.

## *3.3 Connection between personal diagnostic categories and orientations*

In exploring how teachers' language-related orientations and their personal diagnostic categories are connected to each other (research question Q3), we conducted group comparisons for each orientation, and the significant differences are shown in Table 4. Within the mathematical criteria of conceptual and procedural knowledge, no differences were found for any orientation.

With respect to orientation **O1**, the sample of teachers was split into those who assume responsibility for language as a learning goal in their mathematics classroom (**O1+**) and

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those who do not (**O1-**). We hypothesized that **O1-** group might focus more on the surface level of language than **O1+** group. This hypothesis could not be confirmed: The difference is substantial (90% in **O1-** focus on the surface level and 78% in **O1+**), but not significant in the *t*-test. In contrast, the differences for articulating language criteria with discourse practices as categories are highly significant (0% in **O1-** and 16% in **O1+**, similarly for all single discourse practices: 0% vs. 4-8%, with each highly significant). That means that none of the teachers who do not assume responsibility for language as a learning goal in math classrooms has explicitly focused on discourse practices as a component of language. The tendency could be extended, but the extent is surprising nevertheless.

Similar results occur for orientation **O4**: The sample was split into teachers who see language as additional (**O4-**) and those who see language as integral part of mathematics learning (**O4+**). Again, the category uses on the surface level are not very different (84 % vs. 78%, not significant), but for discourse practices (4% vs. 16%, significant) and for single discourse practices they are highly significant, besides reporting procedures, where they are not significant. Additionally, teachers with an additive orientation more often activate the vague category of "mode of expression" (32% vs. 12%, significant).

With respect to orientation **O2**, the sample was split into language pushers (**O2+**) and language reducers (**O2-**). The differences between the two groups were only significant with respect to explaining meanings as a mathematical or language-related category (59% vs. 35%) and the general addressing of discourse practices as a language-related category (4% vs. 16%, significant).

For orientation **O3**, the sample was split into those who mainly agree to items on the word level in the orientation scale (**O3-**) and those who mainly agree to items on the discourse level in the orientation scale (**O3+**). The difference in category use on the word level is visible (36% vs. 24%), but not significant in the *t*-test. Instead, group **O3-** articulates significantly vaguer categories than group **O3+** (49% vs. 36%).

Finally, orientation **O5**, focusing mainly on procedural knowledge (**O5-**) or mainly on conceptual knowledge (**O5+**), has an exact impact on the use of the categories explaining meanings (0% vs. 7%, highly significant) and reporting procedures (0% vs. 8%, highly significant) as language categories. This was to be expected, but is interesting as it referred to language criteria and not also to mathematical criteria. Additional group differences occurred for the vague and functional category understandability (26% vs. 39%, significant).

## 4 Discussion

Although there is an increasing worldwide agreement that subject-matter mainstream teachers should be prepared for supporting language learners in subject-matter teaching (CCSS, 2010; Thürmann et al., 2010), there is still a substantial research gap on teachers' language-related orientations and categories beyond the pure question of whether they assume responsibility for language or not (as indicated in various research surveys,

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e.g., Bunch, 2013; Moschkovich, 2010; Radford & Barwell, 2016). Thus, this article explored which language demands count as relevant for mainstream subject-matter teachers and how they connect them to content requirements.

The questionnaire with orientation scales showed that the majority of our 223 German middle and high school mathematics teachers already hold productive language-related orientations: 90% assumed responsibility for language as a learning goal (**O1**), and 87% considered language an integral part of mathematics learning (**O4**). However, only 48% agreed to strategies of pushing rather than reducing language (**O2**), so simplifications might tend to limit the students' language learning opportunities. Only 39% held an unproductive focus on the word level, while 61% had the discourse level in view (**O3**). These results show that language-related orientations are in principle productive (in contrast to the small sample in Turner et al., 2019), at least among those who volunteer for PD on language. However, further professional development is required in order to develop the ambition to push rather than reduce language and to overcome the pure vocabulary focus (in line with the results of Turner et al., 2019; Bunch, 2013).

These tendencies resonate with the identified diagnostic categories that teachers activate when noticing and evaluating students' written explanations of the mathematical concept slope in an open-ended category-eliciting activity (Kelly, 1955), revealing that teachers activate a large range of criteria that are subsumed under 20 different diagnostic categories.

The often articulated critique on teachers' restriction to the word level (Turner et al., 2019; Bunch, 2013) is not that relevant for our sample, in which only 29% activated word-level categories. However, 79% of the teachers focus on language demands that are peripheral to subject-matter learning, namely surface categories such as orthography and grammar. In contrast, only 14% considered discourse practices a relevant part of language (as problematized by Bunch, 2013; Turner et al., 2019). In terms of discourse practices being a relevant part of language, significant group differences could be identified between those who assumed responsibility for language as language goals or not (**O1-** vs. **O1+ Goals**) and those who already have an integrative perspective on language (**O4-** vs. **O4+ Integrative**). Hence, teachers' unproductive focuses seems to be connected to language-related orientations.

Additionally, it is a very important result that although they were within their mathematical criteria, many more teachers (73%) activated criteria that were identified as belonging to discourse practices. Again, the existing literature on teachers' categorial filters might underestimate the proportion of teachers who already consider discourse practices a relevant part of mathematics learning, even if they have not yet realized that they are part of language. This is a very important seed for teachers' continuous learning and a productive starting point for extending their language views.

Of course, these results are still bound to the methodological limitations of the study, the three most important of which are mentioned here: (a) Because only four orientation scales had acceptable internal consistencies (scale **O2 Push** was reduced to a single item with limited reliability), future research should continue to attempt to improve their consistency. (b) The findings of the open-ended diagnostic activity are bound to

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one single mathematical concept, so future research should investigate how they can be transferred to other subject-matter concepts, in both mathematics and other subjects. (c) Noticing and evaluating students' explanations is only one situational demand teachers have to master in language-responsive classrooms; future research should also explore others.

In spite of these methodological limitations, the results even at this point already call for substantial consequences in professional development that can confirm the hypotheses of Turner et al. (2019) and Prediger (2019): Shifting teachers' language focus towards discourse practices seems to be of major importance in overcoming superficial language views and unproductive teaching practices. However, our research shows that teachers have resources about discourse practice that have so far been ignored (e.g., Moschkovich, 2010): When prompted by contrasting examples of discourse practices, teachers focus on discourse practices, even if still subsumed under mathematical criteria. This substantial finding shows that we have identified a very important starting point to work with teachers' intuitive resources: Teachers do not need to learn about discourse practices as a new object of learning, they only need to widen their language views in order to also subsume the discourse practices under language.

As the current study has only been conducted with mathematics teachers, it should be transferred to other subjects where the most relevant discourse practices might be realized differently. Again, we can expect discourse practices to also be a crucial category in other subjects, as they link mental processes and language (Snow & Uccelli, 2009).

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