



From verbal complexity to student success: understanding the role of linguistic features in teachers' oral classroom explanations

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Abstract

Oral explanations (OE) by teachers are one of the most common forms of communication in the classroom to support students' comprehension of subject-specific content. Thus, students have to deal with the language the teachers use in explanations. Research indicates that linguistic features (LF) of texts can influence students' comprehension as they affect cognitive processes of text comprehension. While the importance of LF of texts has been addressed widely, to date, relatively little attention has been given to the influence of LF of teachers' oral explanations on students' comprehension. We aimed to investigate whether the linguistic design of teachers' OE improves students' comprehension. $N=102$ German students (age: $M=14.04$; 55.9% female) took part in the study. Students watched explanatory videos on the same content but with differing verbal complexity (simple/difficult). The two versions differed in their levels of cohesion and surface features at word and sentence level. After listening to the explanation, students' comprehension was assessed. The results showed that the simpler version of the explanation was associated with significantly higher results in comprehension. The linguistic complexity of explanations affected students' comprehension. The findings suggest that teachers should pay more attention to the linguistic complexity of OE.

Keywords Comprehension · Verbal complexity · Linguistic features · Oral explanations · Text cohesion

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Introduction

About three quarters of instructional time in school is devoted to oral communication (Behrens, 2022). In the education plans of the school subject German, speaking and listening are independent competencies alongside writing, reading, dealing with texts and media, and the development of language (KMK, 2022). Teachers' oral explanations (OE) are useful for introductions, but also for connecting new information with prior content and filling gaps in students' knowledge (Wittwer & Renkl, 2008). Therefore, teachers' explanations are essential for teaching (Leinhardt, 1997; Vogt, 2009). Explaining is considered a central didactic activity, a key skill, and a core task of teachers (Brown, 2011; Charalambous et al., 2011). However, there has been only sporadic research on teachers' explanations, particularly on OE.

Explanations are closely associated with understanding, which is their target dimension (Brown, 2011). Research on explanations indicates a link between the comprehensibility of explanations and student learning outcomes (Hines et al., 1985). Similarly, there is evidence that the effectiveness of explanations depends on their structural design (Wittwer & Renkl, 2008). However, the verbal complexity of OE and the effects on students' comprehension have not been studied. It is known, however, that the linguistic design of texts, referring to both oral and written texts (Wellenreuther, 2007), can challenge learners (Arya et al., 2011; Leroy et al., 2016). Comprehending oral texts is a demanding cognitive process. Due to the transient nature of oral speech, students may find it more difficult to understand information from oral texts than from written texts (Schmitz et al., 2023). However, it is still unknown how the linguistic features (LF) of teachers' OE affect students' comprehension. Drawing on research on written texts, LFs (e.g., cohesion) affect text comprehension (McNamara et al., 2011; Ozuru et al., 2009). These effects have also been demonstrated for informational listening texts (Schmitz et al., 2023).

In this study, we examined the effect of the linguistic design of OE on students' comprehension. For this purpose, we developed two OEs: One oral explanation was linguistically simple and the second one was linguistically more difficult in terms of the LF used (i.e., cohesion, sentence length, passive constructions, genitive constructions, explanation of technical terms).

Oral explanations in the classroom context

Explanations are important means for teachers to convey new content, to show connections to prior knowledge, and to fill knowledge gaps (Leinhardt, 2001; Wittwer & Renkl, 2008). Explanations aim to share knowledge and meaning and to make learners understand content (Leinhardt, 2001). Explanations refer to a content, i.e., the object of explanation. This object can, among other things, aim at making terms, concepts, contexts, processes, or ideas understandable (Hargie, 2011). Furthermore, explanations are influenced by the context in which they are given (Wittwer & Renkl, 2008). They are often given live in the classroom (Leinhardt, 2001) and due to this dynamic "real-time situation" (Leinhardt, 2001, p. 337), explaining is a complex task. Moreover, instructional explanations are often directed at a large group of learners, so that they cannot be adapted to the needs of individual students, making it difficult to ensure comprehension by each individual (Wagner & Wörn, 2011). Likewise, curriculum content and learning objectives influence the explanation process (Wittwer & Renkl, 2008). In classroom explanations, connections between

aspects, for instance in comparison to everyday explanations, have to be made particularly clear or contents have to be illustrated. Technical terms have to be taken into account, but at the same time, they have to be adapted to the learners' level of knowledge (Leinhardt, 2010). Due to these complex requirements for explanations in class, teachers often prepare them in advance (Pauli, 2015).

In this paper, we focus on teachers' OE. These serve to convey new content and not on dialogical interactions with students (Brown, 2011; Leinhardt, 2001). The quality of an explanation depends on several factors, such as the accuracy and relevance of the information conveyed, but also on language, specifically the verbal complexity. In order to achieve students' comprehension, the linguistically appropriate preparation of explanations by teachers may be of particular importance (Hargie, 2011; Leinhardt, 2010).

Linguistic features of oral explanations

In cognitive psychological research (e.g., Kintsch, 1988; van Dijk & Kintsch, 1983), text comprehension is described as a recipient-text interaction. The interaction is characterized by the construction of mental representations on three levels: the surface structure level, the propositional level, and the situation model level. The surface level refers to the syntactic processing of the text, consisting of the directly comprehensible elements of a text. By representing the surface, the text can be reproduced at least theoretically, but without having actually understood it. The propositional level represents the semantic content, which consists of propositions, and the structure of a text. The propositional representations only enable a rudimentary comprehension of the text. At the third level, a situation model is constructed. This represents the text content with reference to a readers' prior knowledge. The construction of a situation model leads to a deeper understanding of the text than the representation of its propositions. Recipients can not only imagine what is said, but also know what is meant. Thus, the process of text comprehension is affected, among other things, by the linguistic and structural nature of the text (Kintsch, 1988; van Dijk & Kintsch, 1983).

Models that explain text comprehension, such as Kintsch's model (1988), can also be applied to the comprehension of oral texts (Clinton-Lisell, 2022; Kürschner & Schnotz, 2008). Since OEs are spoken texts (Wellenreuther, 2007), studies of written texts may be transferable to oral texts meaning that insights of studies on text comprehensibility may also be applied to OE. The underlying processes, such as the integration of new knowledge into existing knowledge structures and the importance of coherence and comprehensibility, are relevant to both reading and listening. In addition, a situation model is formed by the recipients regardless of whether the text has been heard or read (Kürschner & Schnotz, 2008; Schmitz et al., 2023). Although the underlying cognitive processes of understanding written and oral texts share some similarities (Clinton-Lisell, 2022; Leinhardt, 2010), there are also differences between the modalities of orality and writing. Unlike in written texts, the production and reception of OEs take place simultaneously. The temporal and sequential organization of oral texts results in the volatile nature of oral speech (Rubin et al., 2000). The content must always be kept present, be connected, and integrated with what might be heard later (Schmitz et al., 2023). Overall, oral texts place greater cognitive demands on recipients than written texts. This is particularly the case if the text is only heard once. Extracting relevant information from oral texts is therefore challenging (Kürschner & Schnotz, 2008; Schmitz et al., 2023). Due to the limited findings on OE, in the present study, we also refer to findings on written explanations.

Explanations differ in their linguistic design. Therefore, language is a central feature of OE and a key aspect of explanatory quality (Hargie, 2011; Leinhardt, 2010). At the same time, language can become a challenge, since linguistic skills that are required in classroom communication and which may vary between students differ from those required in everyday life (Kleinschmidt-Schinke, 2021a; Marx et al., 2017). The verbal complexity of OE can therefore impede students' comprehension.

How the linguistic design of OE affects the comprehension process has rarely been investigated as yet. When linguistic design is considered, the need to keep the language simple is emphasized (Scheffel, 2019; Schopf & Zwischenbrugger, 2015). An OE should always include linguistic precision and a verbal complexity adjusted to the recipients (Findeisen, 2017; Hargie, 2011). Explanations should be formulated precisely rather than vague and should ensure a good balance between academic and everyday language. Saller (2020) mentions short main clauses and ellipses as features of OE that create greater coherence between the linguistic constituents and thus facilitate the processing and mental categorization of the subsequent content. LFs of explanations and students' comprehension are often related to each other. Schopf (2018), for example, investigated the characteristics of comprehensible and motivating teachers' OE from the students' perspective in accounting lessons. Over one third of the students named LFs, such as simple words, few technical terms, and short sentences, as relevant and helpful aspects of comprehensible explanations. Schopf and Zwischenbrugger (2015) developed a heuristic model of explanations based on expert interviews for economics lessons. All experts indicated linguistic simplicity (e.g., simple syntax, use of frequent words), concentration on the essentials, and structure as characteristics of an accessible explanation. At this point, it is also important to note that linguistically simple OEs cannot always be equated with good explanations and linguistically difficult OEs cannot always be equated with bad OEs. This is mainly due to the fact that good OEs are dependent on several factors, such as the structure of the information conveyed, and not only on the LF used in the OE. Effects of these LF on students' comprehension, however, were not investigated.

Linguistic features supporting text comprehension

It is known that the linguistic design of texts can affect students' comprehension (Cruz Neri & Retelsdorf, 2022). For instance, it is often suggested that familiar words can foster text comprehension (e.g., Langer et al., 2011), while not all studies examining the familiarity of words on students' comprehension can support this claim (see Cruz Neri & Retelsdorf, 2022). Still, authors recommend to use more frequent words since they are more likely to be understood. Other suggestions to simplify texts, i.e., here OEs, are to avoid the genitive and passive constructions, creating sentences with less than 20 words and simple structures. Furthermore, complex syntactic structures (e.g., subordinate clauses) should be avoided (Heine et al., 2018; White, 2012). Additionally, technical terms might cause difficulties for students. However, since they are an integral part of learning a subject, it is not recommended to omit these technical terms completely. These LFs at the surface text level show some overlap with plain language (Plain, 2011). It is important to note that following these guidelines to simplify OEs will not automatically lead to better comprehension. In the systematic review by Cruz Neri and Retelsdorf (2022), it has been shown that for some LFs, empirical evidence has been quite inconsistent. For instance, regarding the word count of test items, the authors showed

that several studies did report negative, positive, and non-significant effects of word count on students' performance in mathematics and science test items.

Some studies focus on the question, if and how text cohesion supports text comprehension as a characteristic of successful explanations (Saller, 2020). In doing so, local and global cohesion are distinguished. Local cohesion means a connection between neighboring sentences or text parts, e.g., through the use of connectives. Global cohesion refers to the structure of content between larger sections of text, e.g., the use of headings (Ozuru et al., 2009; Schnotz, 1994).

Studies have systematically varied the degree of cohesion to investigate its effects on students' comprehension. The results indicate positive effects of higher text cohesion on comprehension (McNamara et al., 2011; Ozuru et al., 2009). A recent meta-analysis showed that cohesion formation is not helpful for texts from the STEM field (Strohmaier et al., 2023). However, there are no equivalent meta-analyses for non-STEM subjects, so it is unclear whether the results can be transferred to German and other subjects. Regarding oral texts, there is first evidence that global cohesion promotes listening comprehension in social sciences (Schmitz et al., 2023).

Two studies focus on cohesion as a relevant linguistic feature of OE. Saller (2020) described the use of lexical, syntactic, and intonational recurrences as well as specific conjunctions and subjunctions as supportive LFs for ensuring comprehension. Gaier (2022) analyzed explaining in the academic subject German and found that a familiar vocabulary and a simple, short-sentence structure enhanced the quality of explanations for students.

In conclusion, cohesion as well as other LFs seem to be of great importance to ensure recipients' comprehension. When receiving OE, learners must develop a situation model (Kintsch, 1988) and therefore deal with the linguistic design of the OE.

The present study

Given the described importance of OE for teaching (Leinhardt, 2001), the challenges of comprehending OE (Rubin et al., 2000; Schmitz et al., 2023), and the difficulties the linguistic design can produce (Cruz Neri & Retelsdorf, 2022), it is important to investigate the effects of linguistic design of OE on students' comprehension. Linguistic simplification could help struggling students to better participate in class (Cawthon et al., 2012) and could support learning of all students.

Based on the theories and findings presented above, we assume that barriers to the comprehension of OE can be reduced by systematically manipulating LF. Given the similarities in the comprehension processes of written and oral texts (Clinton-Lisell, 2022), we aim to investigate whether linguistic simplification of teachers' OE has a positive effect on students' comprehension. We expected that the students would understand a linguistically simple explanation better than the students who heard a linguistically difficult version of the same explanation. Thus, the focus in our study is the systematic manipulation of the linguistic design in OE.

Materials and methods

Procedure

In our experimental study, we presented the OE in two versions (simple/difficult) monologically as a video lecture. The videos were filmed from the semi-close-up. During filming, the camera's settings were not changed. Nonverbal signs, such as gestures, and the

accompanying PowerPoint presentation were consistent in both versions of the explanation to avoid confounding effects on comprehension. Both explanations were given by the same person. Thus, the OEs in this study were recorded on videos to ensure comparability between both testing conditions apart from the linguistic design and should, thus, not be compared to typical instructional videos that are usually developed on the basis of the cognitive theory of multimedia learning (e.g., Mayer, 1999). In our case, it is rather a recorded oral teacher presentation as part of a direct instruction.

We carried out our study out in accordance with the ethical guidelines for research with human participants as proposed by the American Psychological Association and in accordance with the General Data Protection Regulation. Participation was anonymous and voluntary, and we obtained written informed consent from all participants and their parents before data collection. Testing took place in the classrooms of participating schools. Students were randomly assigned to one of the two experimental conditions. The students watched the OE once as a video recording via tablets and headsets without the written text being available. After watching the explanation video, we assessed students' comprehension of the OE.

Sample

As the effect of linguistic design on comprehension was the main focus of our study, we performed an a priori power analysis with G*Power (Faul et al., 2007) to estimate the required sample size with regard to this effect in a linear regression model. Assuming a small to medium effect drawing on previous research, $\alpha=.05$, and power of $\beta=.80$, a total sample of $N=95$ was estimated. In our study, $N=102$ eighth and ninth grade students (55.9% female; age: $M=14.04$, $SD=0.68$) participated. All students attended the academic school track of two schools in Hamburg and Niedersachsen, Germany, which is usually completed with the general university entrance qualification after 12 or 13 years of schooling. Most students (64.7%) reported that they exclusively speak German at home, while 22.5% of the students speak German and other languages at home and 11.8% reported speaking exclusively a language other than German at home.

The participants were randomly allocated to one of two test conditions (simple OE versus difficult OE). Students listening to the simple OE were $M=14.20$ years old ($SD=0.68$) (56.9% female), and 84.3% reported to speak German at home. In comparison, students listening to the difficult OE were $M=13.88$ years old ($SD=0.66$) (54.9% female), and 92.2% reported to speak German at home. Thus, the two groups differed significantly in age, $t(96.79)=2.41$, $p=.018$, but not regarding sex, $t(99)=0.45$, $p=.654$, or family language, $t(100)=1.368$, $p=.174$.

Oral explanations

Two videotaped OEs with the same content but different LF were created in German (see Text S1 and Text S2 in ESM). A topic from German lessons, Schulz von Thun's communication model (Schulz von Thun, 1981), served as the subject of the OE and was not yet familiar to the students. In the curriculum of the subject German for grades 5–10 at grammar schools (secondary level I), the topic belongs to the competence area "Examining language and language use." At the end of year 10, students should know the Schulz von Thun communication model and should be able to use it to analyze communication (Niedersächsisches Kultusministerium, 2015).

We systematically varied LFs that are considered indicators of verbal complexity (White, 2012) between the two versions, more specifically (global and local) text cohesion and LF at the word and sentence level. The manipulation of the explanatory versions was based on Schnotz' (1994) coherence-building guidelines and White's (2012) recommendations. The linguistic design of the two versions is shown in Table 1.

Drawing on the construction-integration model (e.g., Kintsch, 1988), differences in sentence length and the use of genitive and passive constructions become apparent at the surface level. When moving from the surface level to the propositional level, the use of connectives and the avoidance of breaks in coherence become important. The use of nominal recurrences and summarizing texts affects the situational model, as they help to structure the information clearly and comprehensibly.

While the simple explanation consisted of 71 sentences with an average of 11.86 words, the difficult explanation version consisted of 47 sentences averaging 15.85 words (see Table S1 in ESM). Due to the linguistic changes that were made while the technical content remained the same, the texts became longer, the simpler they supposedly were. Both videos had comparable durations (simple, 05:44 min; difficult, 05:46 min).

Both explanations were analyzed with the tool LATIC (Cruz Neri et al., 2022), which supported the assumption of higher verbal complexity of the difficult explanation and the general appropriateness of both explanations for eighth graders (see Table S1 in ESM).

Comprehension test

The comprehension test consisted of 16 items in different formats (multiple-choice, open, half-open) to assess students' comprehension after viewing the OE (see Text S2 in ESM). Six items required identifying and selecting explicitly named information ("replay tasks", e.g., "Who 'invented' the described model?"). Linking information between different parts of the explanation (e.g., "Describe what the factual level contains") was required in the seven "linking tasks." In addition, three "transfer tasks" aimed at linking and reflecting on information from the explanation (e.g., "How could misunderstandings be avoided?") (c.f. Ozuru et al., 2009).

Some items required several correct answers. One point was awarded for each correct answer. Half-correct answers received half a point and incorrectly or unanswered items received no point. The open questions were evaluated using a coding scheme. Students could reach a maximum of 24 points in total. Cronbach's alpha was sufficient, $\alpha = .76$.

Statistical analyses

To examine whether the linguistic design had an effect on students' comprehension, regression models were estimated using Mplus 8.11 (Muthén & Muthén, 1998–2017). In the model, the linguistic version of the OE was included as a dummy-coded predictor (0 = simple explanation, 1 = difficult explanation). Students' comprehension was the dependent variable. There were no missing values for the included variables. In a second model, we included covariates due to some significant differences between the two test conditions, namely, students' age, sex (0 = male, 1 = female), and family language (0 = students speak German at home, 1 = students do not speak German at home). There was a small amount of missing data for the covariates, which was estimated by means of the full information maximum likelihood (FIML) in Mplus.

Table 1 Linguistic differences between versions

No	Simple version	Difficult version	Type of change
1	Connecting clauses and subclauses with connectives and, if necessary, an additional clause to close a break in coherence between two consecutive clauses	Omitting sentence and subordinate clause connections by not using connectives and, if necessary, creating breaks in coherence between two consecutive sentences	Local coherence support
2	Use of (nominal) recurrences for sentence compounds	Use of pro-forms in compound sentences	Global coherence support
3	Use of pre- and summarizing post-texts	Omission of pre- and summarizing post-texts	Text surface features at word and sentence level
4	Use of short sentences	Use of longer sentences, including several subordinate clauses	
5	Technical terms and difficult concepts are avoided or explained	Technical terms that students should know and difficult concepts are used, but not explained	
6	Avoiding passive and genitive constructions	Use of passive and genitive constructions	

Results

The analyses showed significant differences in students' comprehension (see Table 2). In total, students received $M=13.89$ points ($SD=4.89$), with students listening to the simple OE ($M=15.18$, $SD=3.77$) scoring $M=2.30$ points higher in the comprehension test than students listening to the difficult OE ($M=12.77$, $SD=5.58$). Cohen's $d=0.51$ indicates a moderate effect size.

Model 1 in Table 2 showed that the linguistically simple version led to significantly higher comprehension. When including the covariates into our model (Model 2 in Table 2), the linguistic version was still a significant predictor for students' comprehension, while the covariates were not significantly associated with their comprehension.

Discussion

This study investigated the effects of the linguistic design of an OE on students' comprehension. The focus was primarily on (local and global) text cohesion and other LFs at the word and sentence level that are regarded as central criteria for successful comprehension (White, 2012). The results showed a positive effect of a linguistically simple linguistic design on students' comprehension.

Effects of linguistic variation in OE

In this study, linguistic simplification had a positive effect on students' comprehension. Students listening to the simple explanation yielded significantly higher test scores than those listening to the difficult one. This indicates the potential of LFs considered as facilitators of comprehension as a cognitive support, making it easier for students to process OE.

Our study showed that linguistic simplification can be successful in OE and that simple LF can foster students' comprehension. This makes it one of the few studies showing that recommendations for adapting spoken language may also improve students' comprehension (Schmitz et al., 2023). The results are in line with the research of McNamara and Kintsch (1996), Ozuru et al. (2009), and Schmitz et al. (2023), by examining the effects of linguistic simplification on written and oral text comprehension. Despite the fact that

Table 2 Standardized results of models 1 and 2

	Model 1				Model 2			
	β	SE	Z	p	β	SE	Z	p
Intercept	3.12	.23	13.81	<.001	5.77	1.86	3.10	.002
Linguistic version	-0.25	.09	-2.66	.008	-0.27	0.09	-3.11	.002
Age					-0.13	0.09	-1.48	.128
Sex					0.01	0.12	0.08	.940
Family language					0.01	0.07	0.10	.922
R^2	0.06				0.09			

The variables linguistic version (0=simple explanation, 1=difficult explanation), sex (0=male, 1=female), and family language (0=students speak German at home, 1=students do not speak German at home) were dummy-coded

different LFs were chosen to linguistically simplify the OE, the results consistently showed that more cohesive texts fostered students' comprehension in both written and oral texts. This result can be explained by local and global cohesion supporting coherence and thus also text comprehension. However, apart from Schmitz et al. (2023), all previous findings related to written texts. By focusing on OE, our study mainly ties in with the study by Schmitz et al. (2023), who also investigated the effects of LF on comprehension using high and low cohesive listening texts. Both studies showed that all students benefit from higher global cohesion.

However, comparing studies is challenging due to variations in the linguistic simplifications used in the different studies. In our study, not only the degree of cohesion between the statements was varied, but also other LFs (e.g., sentence length) drawing on the different levels of representation proposed by the construction-integration model by Kintsch (1988). While McNamara and Kintsch (1996), for example, focused on both local and global cohesive devices, Schmitz et al. (2023) examined global cohesive devices only. Particularly in the studies that focused exclusively on global cohesion means, the resulting limitation of comparability with this study must be considered.

The results of the present study are in line with research emphasizing the need for clear and simple OE (Langer et al., 2011; Schopf, 2018). The question of what characterizes clear, simple, and comprehensible explanations could be presented more linguistically in the context of this work. Their design should be based on connections between text elements, e.g., through cohesion, and surface structures (e.g., short sentences). The results support Gaier's (2022) assumption that vocabulary and sentence structure also have an effect on the comprehensibility of OE. Furthermore, the results emphasize the relevance of specific LFs (e.g., simple words) for comprehensible OE to students.

Implications for teaching practice

In view of the little research on this topic to date, our study can provide a basis for further research. Due to the need for further research on OE and the promotion of comprehension, only tentative pedagogical conclusions can be drawn from our results.

Since OE cannot be customized for each student individually, it is important to identify appropriate LF to specifically support learning with OE and the construction of a coherent situation model (Kintsch, 1988). Our study was able to show that local and global cohesive devices, but also other LFs at the word and sentence level, have an impact on comprehension and can be regarded as LFs of comprehensible OE. These include sentence and sub-sentence combinations using connectives, the use of nominal recurrences, pre- and summarizing post-texts, the use of short sentences, the avoidance of technical words and difficult terms, and passive and genitive constructions. Considering the key function of OE for learning processes in school (Leinhardt, 2010; Wittwer & Renkl, 2008), these results are highly relevant for supporting students in acquiring and expanding new knowledge through oral teacher explanations.

From the results, we can derive recommendations for German lessons and maybe school lessons in general regarding the design of comprehensible OE. Teachers have decisive influence on students' comprehension by deciding how to orally convey subject content in their lessons (Kleinschmidt-Schinke, 2021b). They should be aware that OE can present challenges for learners due to their linguistic requirements. For developing OE, this means

that LF, which might cause difficulties, should be used appropriately. In particular, the use of nouns instead of pronominal referents and summaries of sections can be easily implemented (Schmitz et al., 2023). For targeted work with LF, it is necessary for teachers to be able to assess the linguistic requirements of their explanations (Brandt et al., 2023), to master design possibilities, and to practice and reflect on their implementation in a targeted manner. A recommendation for the design of OE, as it emerges from our work in a rudimentary and exemplary manner, is a suitable means to be ideally considered in the preparation and design of these features and components.

Thus, raising teachers' awareness for the role of LF is essential for fostering students' comprehension. This can be done, for instance, in initial teacher trainings or even continuous teacher trainings. Pre-service and in-service teachers could be encouraged to implement reflection prompts, such as "How clear was this explanation to a novice learner?" or "What strategies did I use to make my explanation more accessible?" This could be, for instance, reflected after hospitations of teacher educators after classes that were led by pre-service teachers. Outside of the classroom, role-playing exercises could support pre-service and in-service teachers to practice giving OE, followed by peer feedback focusing on clarity and linguistic complexity. Here, the incorporation of video analyses can further enhance awareness of accessible OE by giving teachers the opportunity to see how they articulate their OE and how they improve over time. Embedding these activities within professional development programs could systematically improve teachers' abilities to communicate complex concepts clearly, ultimately supporting diverse learners' understanding.

Limitations

The limited generalizability of our results must be taken into consideration and should be accounted for in future studies. First, numerous changes were made to the explanations regarding the LF. This means that it is not possible to differentiate exactly which LF alone or in combination with others was the cause of the found effects. It is therefore not possible to make any statement about the strength of individual linguistic effects on comprehension. However, it seems plausible that OEs usually do not differ in one particular LF only, so that rather the general level of verbal complexity is relevant for comprehension and not one piece of the puzzle. Thus, the ecological validity of our study might be higher. A detailed investigation of the effects of specific LF on students' comprehension would be desirable in order to develop suggestions as to which of them should be considered in OE.

In addition, the selection of students in eighth and ninth grades in academic track schools might have led to a rather homogeneous sample. Furthermore, our experiment was conducted using a single topic from German lessons. Future studies should investigate whether similar effects can be found for students of other age groups and school types as well as for different content or school subjects to get more evidence for the generalizability of our results.

Finally, the methodological choice to present OE using videos needs to be addressed. This differs from real-life classroom situations with teacher-student interaction. However, our aim was to standardize the OE for an experimental study in this context. Future studies may examine whether similar results can also be found in more spontaneous or interactive settings, maybe by using video-recordings of real classroom explanations to analyze the difficulty of the teachers' language and relate it then to students' comprehension.

Conclusion and outlook

The results of our study suggest that the use of simple LF has a positive effect on students' comprehension. For learning with OE, identifying suitable LF that support the cognitive processing of OE is important. Recommendations for the design of comprehensible OE by teachers can be derived from the results. Future research should not only use the test instruments again with different populations, but extend them to OE with different content. Such an investigation would allow comparisons, enabling more profound insights into the linguistic design of the OE and their learning benefits. It is also worthwhile to investigate whether the LFs we varied in this study are already included or considered in the OE of teachers. By doing so, we would gain insights that contribute to our understanding of effective language use in everyday school practice.

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Declarations

Ethics approval and consent to participate, consent for publication We carried out our study out in accordance with the ethical guidelines for research with human participants as proposed by the American Psychological Association and in accordance with the General Data Protection Regulation. Participation was anonymous and voluntary and we obtained written informed consent from all participants and their parents before data collection.

Competing interests The authors declare no competing interests.

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Current themes of research:

Role of language in education. Reading methods

Most relevant publications in the field of Psychology of Education:

- not applicable -

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Current themes of research:

Role of language in mathematics and science performance. Predictors of linguistic skills. Learning disorders. Diversity in the school context

Most relevant publications in the field of Psychology of Education:

Cruz Neri, N., Schwenke-Lam, T., & Fürstenau, S. (2025). Predictors of multilingual classroom practices of German primary teachers. *International Journal of Educational Research*, 129, 102500. <https://doi.org/10.1016/j.ijer.2024.102500>

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Current themes of research:

Role of language in education. Inclusive schooling. Teacher education. Data literacy

Most relevant publications in the field of Psychology of Education:

- Brandt, H., Ehmke, T., Kuhl, P., & Leutner, D. (2024). Pre-service teachers' ability to identify academic language features: the role of language-related opportunities to learn, and professional beliefs about linguistically responsive teaching. *Language awareness*, 33(1), 70–93.
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Current themes of research:

Text comprehension in science and mathematics. Stereotypes and judgment biases in the school context. Motivation and self-regulation for learning and performance

Most relevant publications in the field of Psychology of Education:

- Cruz Neri, N., & Retelsdorf, J. (2022). The role of linguistic features in science and math comprehension and performance: a systematic review. *Educational Research Review*, 36, 100460. <https://doi.org/10.1016/j.edurev.2022.100460>
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