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Barriers to Understanding in Biology School Textbooks and How to Lower Them Using Easy Language

Abstract

As texts in biology classes can contain many barriers to understanding, the concept of Easy Language ('Leichte Sprache') is currently discussed for use in schools. This article analyses comprehensibility barriers exemplary in standard school textbooks and highlights how translations into Easy Language can be realized and how they correspond to the educational standards. Overall, such translations seem to be promising, although some aspects still need further research and discussion.

Da Texte im Biologieunterricht viele Verständlichkeitsbarrieren enthalten können, wird derzeit das Konzept der Leichten Sprache für den Einsatz in Schulen diskutiert. Der Artikel stellt exemplarisch Ergebnisse einer Analyse von Verständlichkeitsbarrieren in Schulbuchtexten vor. Er geht auch der Frage nach, inwiefern Übersetzungen in Leichte Sprache realisierbar sind und ob diese den Kerncurricula entsprechen. Die Übersetzungen scheinen vielversprechend zu sein, auch wenn einige Aspekte diskussionswürdig sind.

Schlagwörter:

Easy Language, barriers to understanding, biological education
Leichte Sprache, Verständlichkeitsbarrieren, Biologieunterricht

1. Introduction

In 2015, school performance studies such as PISA (Programme for International Student Assessment) or TIMMS (Trends in International Mathematics and Science Study) demonstrated that Germany ranks top third internationally in the area of reading and science-related skills (OECD, 2016; Stubbe, Schwippert & Wendt, 2016). However, this only applies to students from families with a high level of education and without a migration background (OECD, 2016; Stubbe et al., 2016). Regarding students with a migration background and students from educationally disadvantaged families, studies ascertained that they perform worse in science (OECD, 2016; Wendt, Schwippert & Stubbe, 2016). Little research exists on the degree to which other student groups are affected by inequality in opportunities, which may be intensified by the realisation of inclusion in biology lessons established by the UN Convention of Rights for Persons with Disabilities (CRPD, 2006). Nevertheless, similar results can be assumed here as teachers generally complain that their students do not understand school textbooks (Rosebrock, 2015; Schroeter-Brauss,

Wecker & Henrici, 2018). It is assumed that the learners' less-developed linguistic competences and the high-level linguistic features of science lessons are primarily responsible for performance disparities (Schroeter-Brauss et al., 2018). Leisen (2017) even goes so far as to attribute the greatest cause of (in)comprehension of school textbooks to textual features.

Biology school textbooks contain both technical and everyday language. While biology-related technical language is needed to describe complex biological phenomena, it may create barriers to comprehension for (at least some) students (Beese, Kleinpaß, Krämer, Reschke, Rzeha & Wiethoff, 2017; Bickes, 2016; Schroeter-Brauss et al., 2018). These can be found on the word, sentence and text levels and are described in the following.

2. Barriers to Understanding in Biology School Textbooks

Characteristics of technical language in biology school textbooks are usually divided according to properties at the word, sentence and text level and occasionally at the layout level (e. g., Bickes, 2016). At the word level, a high number of technical terms prevails, some of which are composed of foreign words or are combinations of different special characters, e. g., CO_2 emission (Bickes, 2016; Graf & Berck, 1993). The problem is that the number of technical terms hardly overlap between the topics covered in class (Graf & Berck, 1993) and are introduced with insufficient or missing definitions (Schmellentin, Dittmar, Gilg & Schneider, 2017). Furthermore, synonyms, which are used extensively, can complicate the comprehension of biology textbooks (Göpferich, 2019; Graf, 2015). Additionally, at the word level, there are different types of derivations, such as nominalisation, e. g., 'Trockenheit' (= 'dryness'), that serve to economize within the technical language. However, they can additionally complicate text comprehension (Drumm, 2016; Fang, 2007).

Furthermore, compounds are frequently observed in biology texts. Compounds, such as 'Fotosynthese' (= 'photo synthesis'), are words composed of two or more words/word stems. Word components must first be identified as such by the students and then understood. In some cases, the reception of biological compounds is already difficult as Schmellentin et al. (2017) found that students slowed down their reading speed when confronted with compounds.

Moreover, borrowings from everyday language, i.e., words that have a different meaning in everyday life than in technical language (e. g., 'cell'; Beese et al., 2017; Childs & Ryan, 2016; Fang, 2007), can make comprehension of biology textbooks more difficult. Metaphors and metonymy that comprise a high amount of information and cannot be understood due to a possible lack in cultural knowledge background may also pose barriers to understanding (Fäßler, 1999; Harms & Kattmann, 2013; Rink, 2018). Additionally, the use of short words and symbols, such as 'DNA', can negatively influence text comprehen-

sion if they are unfamiliar to students (Beese et al., 2017). Similarly, genitive and subjunctive (the German 'Konjunktiv') constructions can decrease comprehensibility (Göpferich, 2009; Schroeter-Brauss et al., 2018).

At the sentence level, complex subordinate clause structures make it difficult for students to decode the content (Beese et al., 2017; Schmellentin et al., 2017). Moreover, information density at the sentence level is furthered by (complex) adjuncts, such as those in the form of attributes (Drumm, 2016; Fang, 2007). A complicating factor for subordinate clauses is the use of separable verbs: meaningful verb components are shifted to the end of the sentence and are thus often overlooked by students, although they are typically crucial for understanding the whole sentence (Bickes, 2016; Beese et al., 2016).

The frequent use of prepositions can be challenging for students as well; important differences in meaning are conveyed by small words but may not be recognized (Fang, 2007). In particular, students with a native language other than German are used to different word orders when it comes to prepositions (Beese et al., 2017).

Moreover, technical language in biology is characterized by an objective, distanced style, which is promoted by the use of impersonal expressions among other features (Kniffka & Roelcke, 2016). However, according to Fang (2007) and Beese et al. (2017), passive constructions can be difficult for students to understand. One reason for this is that the passive voice is introduced in German classes for the first time in seventh grade, when students are about 12–13 years old, and is from then on successively understood as the class and age increases (Beese et al., 2017).

Biology classes mainly offer text types that students hardly or never experience in their everyday lives and that are specifically used in science classes, e. g., non-fictional texts or experimental protocols. These texts usually have a specific structure that students must first become familiar with and include cohesive devices (forms of reference such as 'these' and 'therefore') that must first be interpreted correctly (Schmellentin et al., 2017). Moreover, images are often positioned to meet specific layout criteria. As a result, the image-text positions are adjusted according to layout criteria rather than content, thus making connections between text and image harder to grasp (Schmellentin et al., 2017).

3. Language-Sensitive Biology Teaching Using Easy Language?

The project described in this article is part of the BRIDGES project (Universität Vechta, n. d.) at the University of Vechta.[1]

In the project, 14 characteristics for successful inclusive teaching were formulated by members of numerous education-related disciplines, including the characteristic of 'language and language sensitivity' (Baumert et al., 2018). According to the researchers, inclusion concerning lingual competences can succeed within (subject) lessons by consid-

ering individual linguistic prerequisites of the students and teaching the lessons accordingly, as well as by successively promoting the use of the subject language (Baumert et al., 2018). This is reminiscent of the goals of language-sensitive subject teaching, which sees the consideration of language and language learning as indispensable within the education in subject teaching (e. g., Leisen, n. d.; Michalak et al., 2015; Schmölzer-Eibinger & Langer, 2010; Vollmer & Thürmann, 2013).

Regarding overcoming challenges that arise within texts in subject lessons, a basic distinction is made between two strategies of language-sensitive subject teaching: first, the adaptation of the reader to the text (offensive strategy) and second, the adaptation of the text to the reader (defensive strategy) (Leisen, 2017). The former is accomplished by training students to employ strategies to decode and understand a text, and the latter involves the simplification/adaptation of texts oriented to the individual reading skills of the students (Leisen, 2017). In this regard, pedagogies offer some recommendations and suggestions for the simplification of texts in the school context in different (scientific) subject didactic works (e. g., Beese et al., 2017; Leisen, 2017).

Accordingly, the concept of 'Leichte Sprache' (= 'Easy Language'; Maaß, 2020) for the simplification of texts is becoming increasingly popular in society as can be observed, for example, when visiting governmental websites or the increasingly strong legal anchoring to lower barriers in media (Bundesamt für Justiz, 2019; 2021). Easy Language is a written variety of German for a simplified perception and reception of texts based on certain rules (e. g., Maaß, 2015a), and it primarily addresses people to whom standard texts are not (fully) perceptible and comprehensible enough (Bredel & Maaß, 2016a). These include people with cognitive impairments, dementia, prelingual hearing impairment or deafness, aphasia, illiteracy, learning difficulties or German as a second language (Bredel & Maaß, 2016a). Some of these target groups are found in German schools as a result of migration and inclusion.

Easy Language has three main functions: participation, learning and bridging (Bredel & Maaß, 2016a). The first function serves to overcome communication barriers and thereby offers access to the content of texts (Bredel & Maaß, 2016a). The learning function is realised when people are encouraged to read by offering them texts in Easy Language and thereby enabling them to improve their reading competences (Bredel & Maaß, 2016a). The bridging function is realised when texts in Easy Language serve as effective alternatives to standard-language texts by being similar to them in terms of structure and content (Bredel & Maaß, 2016a). In this way, texts in Easy Language can also be used temporarily when difficulties are encountered in the source text (Bredel & Maaß, 2016a).

Presently, Easy Language is increasingly becoming part of the discourse in the context of inclusive school teaching (e. g., Abend, 2018; Riegert, 2019). Therefore, the evaluation of Easy Language by the pedagogies regarding possible opportunities and difficulties in the context of inclusive teaching is becoming increasingly interesting (Maaß, 2015b). First indications of the implementation of Easy Language in science education

already exist (Härtig, Fraser, Bernholt & Retelsdorf, 2019). The following presents insight into a research project about the implementation of Easy Language in biology lessons.

4. How Easy Language Can Lower Barriers to Understanding in Biology School Textbooks

The rules of Easy Language, provided by Maaß (2015a)[2], can address some of the previously described linguistic challenges in biology school textbooks (Schaller, Görries & Ewig, 2019; Schaller & Ewig, 2020; Table 1), although existing translations into Easy Language have so far largely addressed everyday and/or legal matters only (Bredel & Maaß, 2016b). The following briefly presents some correspondences between the linguistic challenges encountered in biology school textbooks and Easy language rules. Reference is made only to the written language of a text. Reference to the content of pictorial representations is left out as text-image coordination is a different competence than the pure reading competence (Hackemann, Heine & Höttecke, 2020). Only their content-related positioning will be noted.

At the word level, for example, the difficulty to understand technical terms can be eased by explaining them. Synonyms can be eliminated by constantly using the same terms for the same concepts. Compounds can be facilitated using a symbol introduced by the Research Center on Easy Language in Hildesheim: the 'mediopoint', as in 'Insekten·fresser·gebiss' (= 'insecti·vore teeth'). At the sentence level, subordinate clause constructions can be resolved according to the rules of Maaß (2015a). Passive forms can be replaced by explicitly naming the actors of the sentence. At the text level, comprehensibility problems can be reduced by naming the subjects and objects of a sentence concretely and constantly instead of using forms of cohesion, e. g., personal pronouns.

	Challenges in biology school textbooks	Rules of Easy Language
Word level	Technical terms, loan words, technical language phrases	Avoid or, if relevant to the text, explain in reading direction; support with images if necessary.
	Metaphors, metonymy and reinterpretations from everyday language	On metaphors: if the metaphor is known to the target group, then it is usable.
	Short words/symbol use	Abbreviations that are used orally/ phonetically in everyday life may be included in the translation, others may be dissolved.
	Synonyms	Avoid synonyms by using the same terms for the same issues.
	compounds	Avoid words longer than two syllables or, if central to the text, use them with a 'medio·point'.

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[2]   This article is based on the rule book by Christiane Maaß from 2015 *(Leichte Sprache. Das Regelbuch.)*, as this is the most comprehensive rulebook freely accessible online to date.

	Derivations, e. g., nominalisations or the addition of prefixes and suffixes	Avoid words longer than two syllables or, if central to the text, use them with a 'medio·point'. Avoid nominal style, and resolve verbally or explain afterwards.
	Subjunctive and genitive usage	Avoid.
Sentence level	(Complex) additions to nouns by adjectives and attributes	Avoid complex sentences as much as possible; for example, follow the rules of 'only one statement per sentence' and use a 'subject-predicate-object' sentence structure (S-P-O). Distribute information over several sentences.
Sentence level	Prepositions	-
Sentence level	Functional verb structure	-
Sentence level	Separable verbs	Avoid complex sentence structures; replace separable verbs with non-separable verbs that adhere to the S-P-O sentence structure and occupy only the left-hand verb position.
Sentence level	Impersonal expressions, such as the passive tense, passive forms and the indefinite pronoun 'man' (= 'one')	Avoid passive forms; name the subject/actors.
Sentence level	Subordinate clause constructions	Dissolve subordinate clauses according to certain rules of the rulebook (strategies exist for conditional, causal, modal, temporal, consecutive, concessive and relative clauses).
Text level	Forms of cohesion such as references to objects and subjects ('she', 'his', etc.) and to justifications or contrasts ('therefore', 'whereas', etc.)	Avoid third-person pronouns (exception: the polite form of addressing a person with 'Sie' or the use of the expletive 'Es' [= 'it']); in general, make information explicit.

Tab. 1: Comparison of linguistic challenges in biology school textbooks and rules of Easy Language (own compilation based on Beese et al., 2017; Bickes, 2016; Bredel & Maaß, 2016a; Maaß, 2015a; Schaller, et al. 2019; Schaller & Ewig, 2020)

5. Study: Effectiveness of Biology School Textbooks in Easy Language

In theory, it is viable to reduce language barriers within biology school textbooks through the use of Easy Language; therefore, a research project at the University of Vechta investigates the use of texts from school books translated into Easy Language in fifth-grade biology classes. The fifth grade is a particularly interesting year because the German students move from the 'Grundschule' (elementary school), where all students are taught together, to one of the several different types of school, e. g., 'Hauptschule', 'Realschule',

'Gymnasium', 'Förderschule', etc. Also, from the fifth grade on, the use of technical language is successively increased and required by the educational standards (NKM, 2015).
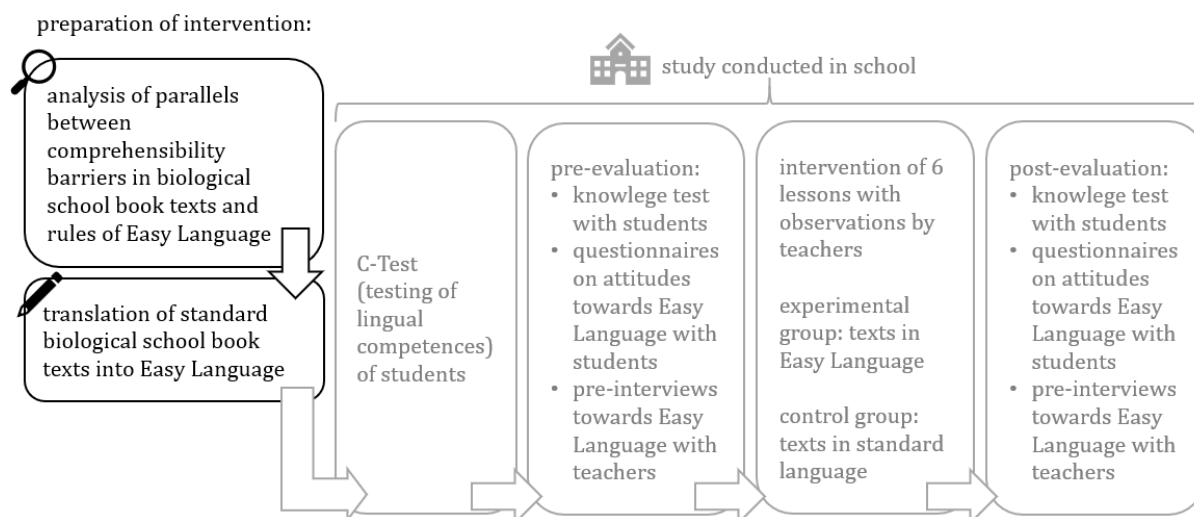

Fig. 1: Preparations of intervention and study design (black writing: focus of the article at hand)

The research project is designed as a pre-post-study with mixed methods and evaluates the influence of texts in Easy Language on the growth of students' content knowledge in inclusive classes at secondary schools (Figure 1). Moreover, it examines the attitudes of the students and biology teachers towards Easy Language in biology lessons. For the intervention, translations into Easy Language were created before the study started. First, the source texts were searched for possible comprehension barriers and then translated according to the rules of Easy Language (Maaß, 2015a; see appendix). The texts of the teaching unit deal with various adaptations of different vertebrates, e. g. squirrels, woodpeckers, whales, etc. The control group was taught with the standard-language texts, while the experimental group received the texts in Easy Language. The source texts were taken from *PRISMA Biologie* (Bergau, Bohm, Geissler, Hagen, Mai-Gebhardt, Röhrich & Schäfer, 2012) as at that time, the 2012 edition of this book was used in the studied schools. The following section outlines the barriers found in the standard texts and the translation process.

5.1 Research Questions

The text analysis aimed to identify possible barriers to comprehensibility in the chosen biology texts: What possible barriers to comprehensibility can be found in biology school textbooks for fifth graders on the word, sentence and text level? After identifying possible comprehensibility barriers in the corpus, the texts were translated into Easy Language. The process was documented by distinguishing between the following: 1.) To what extent can biology texts from school books be translated into Easy Language? 2.) To what degree

can the content-related basic concepts and language-related competences specified by the state of Lower Saxony (Germany) be promoted through the translated texts?

5.2 Methods

The analysed corpus of the main study consisted of six texts on animals adaptions to their environment from school books for fifth-grade biology classes (1,845 words and 7,632 characters with spaces). Possible comprehensibility barriers in the texts were identified through the structured content analysis (cf. Mayring, 2015) with the use of deductive categories derived from both theoretically (e. g. Göpferich, 2009) and empirically (e. g., Schmellentin et al., 2017) defined barriers to comprehensibility encountered by students in biology school textbooks. The following deductive categories were formed regarding the word level:

- Technical terms, loan words, technical phrases
- Metaphors, metonymy, reinterpretations from everyday language
- Short words, symbols
- Synonyms
- Compounds
- Derivations
- Subjunctive, genitive

On the sentence level, the following categories were derived from the literature:

- Additions by adjectives/attributes
- Prepositions
- Functional verb structure
- Separable verbs
- Impersonal expressions
- Subordinate clauses/more than one main clause.

On the text level, the category 'forms of cohesion' was composed deductively. The categories related to the word level could all be coded by one or two words of the corpus. This also applies to the categories 'prepositions' and 'functional verb structure' at the sentence level and the 'forms of cohesions' at the text level. 'Additions by adjectives/attributes' comprise longer parts of sentences, depending on the length of the phrase in question. Separable verbs were coded from the beginning of the verb (the word stem) to the prefix at the end of the (sub)clause. Impersonal expressions were partly coded as a whole (sub)clause unless only the impersonal expression 'man' (= 'one') was used. Subordinate clauses were coded as a whole unit. If there was more than one main clause in a sentence, the second main clause was coded as a whole. Coding was done using the analysis software MAXQDA 2020. With the tool 'Code-Relations-Browser' within MAXQDA, it was further possible to display multiple assignments of segments to categories, indicating multiple barriers within a word/phrase.

A trained translator translated the texts into Easy Language following the rules by Maaß (2015a). The process was documented in a table that records the implementation of the rules for each translated text passage (sentence by sentence) to check the extent to which the rules of Easy Language could actually be applied to the texts.

Afterwards, the translated texts were examined to determine if they still met the requirements of the given educational standards. For this purpose, the texts' content and language were compared with the specifications for the content-related (structured by basic concepts) and language-related competences of the curriculum of the state of Lower Saxony for the subject biology in secondary schools ('Realschule'; NKM, 2015). In this way, it could be determined to what extent the basic concepts are represented throughout the translated texts and how the development of language-related competences is supported/hindered by the translated texts. However, only the basic concepts and language competences that are related, first, to the animal's adaptions and, second, to text work were considered, i.e., competences that can be developed based on the translated texts. These were formed into deductive categories and analysed via structured content analysis according to Mayring (2015) using MAXQDA 2020. The following categories based on the NKM (2015) were considered:

- Communication
  - Use of biological terms in the correct context
- Basic concept 'system'
  - Describing the characteristics of the living
  - Describing organs and their interaction in the organism
  - Naming animal species in their habitat
  - Representing food chains and food webs
- Basic concept 'structure and function'
  - Explaining the relationship between the structure and function of organs based on types of dentition
  - Describing the energy loss to the environment as a function of body surface area
  - Describing the communication of animals with species-specific signals
  - Classifying animals according to their ability to regulate their body temperature
- Basic concept 'development'
  - Explaining the adaptations of living organisms to seasons and their habitat
  - Comparing domestic animals with wild forms and deriving aspects of species-appropriate animal husbandry from them
  - Naming important distinguishing features and common features of vertebrate classes

6. Results

The results are presented in two parts. First, the results of the analysis of possible comprehensibility barriers are described. Then, the extent to which the translation of the texts into Easy Language was feasible is outlined. Finally, the extent to which the standards of the educational system in Lower Saxony are still met within the translations is reported.

6.1 Analysis of Possible Comprehensibility Barriers

A total of 63% of all six texts were coded with the deductive categories referring to possible language comprehension barriers. Therefore, the distribution of coded and non-coded sequences is mostly similar between the analysed texts. The percentage of coded text is the lowest in the text on moles (48%), and it is the highest in the text on squirrels (77%). Thus, although the text on squirrels is the shortest, it still demonstrates the highest percentage of possible text comprehension barriers. In the other texts, the coded segments take up between 61–66% of the total scope of the texts (see Table 2). A large proportion of the coded sequences could be attributed to possible language comprehension barriers at the word (46%) and sentence level (44%), with only 3% at the text level (Table 2).

The most comprehensive category in terms of the number of codes is the category of compounds (138 codes), closely followed by the category of technical terms and foreign words with 107 codes and 98 codes within the category of prepositions. The categories 'functional verb structure' (two codes), 'subjunctive/genitive' (six codes) and 'impersonal expressions' (six codes) demonstrated the least number of codes that were also not present in each text. If the percentage of coding of corresponding categories is considered for the whole corpus, the category of compounds is again the most extensive category with 20% coverage of text volume, followed by the category 'subordinate clauses/more than two main clauses' (15%) and the category 'technical terms, loan words' (13%), as well as 'additions to words' (12%). Abbreviations, metaphors, the use of genitives/subjunctives, functional verb forms, synonyms, impersonal expressions and forms of cohesions cover only between 1–3% of the total text volume, which can be partly explained by the length of the according word forms.

Categories/ documents	Whales	Wood-pecker	Beaver	Bats	Squirrels	Mole	Total
Technical terms, loan words, technical phrases	29 (19%)	29 (20%)	14 (9%)	14 (13%)	5 (5%)	16 (11%)	107 (13%)
Metaphors, metonymy, reinterpretations from everyday language	3 (2%)	6 (4%)	2 (1%)	0 (0%)	0 (0%)	1 (1%)	12 (2%)

Short words, symbols	4 (1%)	2 (0%)	5 (1%)	2 (1%)	2 (0%)	5 (1%)	20 (1%)
Synonyms	4 (5%)	4 (2%)	3 (2%)	5 (4%)	2 (2%)	1 (1%)	19 (3%)
Compounds	22 (16%)	29 (22%)	33 (22%)	24 (26%)	16 (24%)	14 (13%)	138 (20%)
Derivations	7 (5%)	8 (6%)	15 (8%)	7 (6%)	3 (3%)	7 (5%)	47 (6%)
Subjunctive/ genitive	0 (0%)	2 (2%)	0 (0%)	1 (2%)	2 (3%)	1 (1%)	6 (1%)
Additions by adjectives/ attributes	19 (19%)	14 (11%)	16 (11%)	9 (9%)	3 (6%)	13 (13%)	74 (12%)
Prepositions	14 (3%)	13 (2%)	31 (5%)	16 (4%)	9 (3%)	15 (4%)	98 (4%)
Functional verb structure	0 (0%)	0 (0%)	0 (0%)	1 (2%)	1 (3%)	0 (0%)	2 (1%)
Separable verbs	4 (11%)	5 (13%)	4 (9%)	1 (3%)	3 (13%)	1 (3%)	18 (9%)
Impersonal expressions	1 (6%)	2 (5%)	0 (0%)	1 (0%)	1 (9%)	1 (2%)	6 (3%)
Subordinate clauses/ more than one main clause.	4 (10%)	1 (5%)	7 (27%)	4 (14%)	3 (35%)	2 (7%)	21 (15%)
Forms of cohesion	12 (3%)	6 (2%)	13 (3%)	8 (3%)	3 (1%)	19 (6%)	61 (3%)
Not coded	34%	34%	36%	39%	23%	52%	37%
Coded	66%	66%	64%	61%	77%	48%	63%
Codes in total	123	121	143	93	53	96	629

Tab. 2: Occurrence of language difficulties in all analysed texts (absolute and relative numbers)

Strikingly, when considering multiple assignment to categories, it becomes clear that in particular, the categories 'technical terms, …' and 'compounds' overlap with a total of 69 codes (Table 3). Multiple assignments to categories including more than ten overlapping codes were also found for the category 'subordinate clauses' in connection with 'compounds', 'derivations', 'prepositions' and 'forms of cohesion'.

Categories	Technical terms, ...	Metaphors, ...	Short words, ...	Synonyms	Compounds	Derivations	Subjunctive/genitive	Additions ...	Prepositions	Functional verb ...	Separable verbs	Impersonal ...	Subordinate ...	Forms of cohesion
Technical terms, ...	0	7	0	4	69	4	1	2	1	0	7	6	7	0
Metaphors, ...	7	0	0	3	5	1	0	1	1	0	0	0	1	0
Short words, ...	0	0	0	0	0	0	0	4	0	0	0	0	6	0
Synonyms	4	3	0	0	4	0	1	3	0	0	1	0	5	2
Compounds	69	5	0	4	0	7	1	8	0	2	7	5	17	0
Derivations	4	1	0	0	7	0	0	5	0	0	2	0	13	0
Subjunctive/ genitive	1	0	0	1	1	0	0	2	0	0	1	0	0	2
Additions ...	2	1	4	3	8	5	2	0	4	0	1	3	10	5
Prepositions	1	1	0	0	0	0	0	4	0	0	8	1	16	1
Functional verb ...	0	0	0	0	2	0	0	0	0	0	0	0	2	0
Separable verbs	7	0	0	1	7	2	1	1	8	0	0	0	4	3
Impersonal ...	6	0	0	0	5	0	0	3	1	0	0	0	1	1
Subordinate ...	7	1	6	5	17	13	0	10	16	2	4	1	0	12
Forms of cohesion	0	0	0	2	0	0	2	5	1	0	3	1	12	0

Tab. 3: Multiple assignments to categories (absolute numbers)

In the following, a specific example is given with a lesson text on the topic 'moles' (204 words, 1,270 characters with spaces). A total of 27.4% of the text volume is made of additions to nouns in the form of 13 attributes and mostly adjectives as in 'weit verzweigten Gängen' (= 'widely branched corridors') and 'etwa 15 cm langer Körper' (= 'about 15 cm long body'). The second largest category within the text is made of compounds (26.3% of the text volume); in this regard, 14 compounds were found in the text, among them mostly compounds with two word stems as in 'walzenförmig' (= 'cylindric') and 'Grabfüße' (= 'digging feet'). The text contains 16 technical/loan terms and phrases (23.2% of the text volume), such as the compounds 'Sichelbein' (= 'prepollex', an extra claw on the mole's

feet) and 'Tastsinn' (= 'tactile sense') and the loan word 'Spezialist' (= 'specialist'). One subordinate clause, a temporal phrase, was noted as well as one sentence with two main clauses connected with the conjunction 'and'. Additionally, 19 forms of cohesion (6% of the text volume) were observed, mostly personal and possessive pronouns referring to the mole or its characteristics as well as adverbs such as 'deshalb' (= 'therefore') or 'damit' (= 'with this'). Derivations (seven in total, 5% text coverage) were found for nouns in forms of nominalizations ('Dunkelheit' = 'darkness') and adjectives ('verzweigten' = 'branched') as well as verbs ('vergraben' = 'bury'). Furthermore, 15 prepositions were found (8% of text volume). The categories 'separable verbs', 'impersonal expressions', 'short words/ abbreviations', 'metaphors/metonymy/reinterpretations of everyday language', 'synonyms' and 'subjunctive/genitive' only covered 7% or less of the text volume. Functional verb structures were not found.

6.2 Translation into Easy Language

In total, the translations resulted in a text corpus of 2,141 words and a character count of 14,142 with spaces. This section describes, in general, the translation process following the rule book by Maaß (2015a) and provides some specific text examples.

The specifications for typography and layout could be implemented well and easily in all translated texts. The texts were left-aligned and almost every sentence could be displayed within one line. Word separations at the end of a line were avoided. Explanations and examples were indented. The setting font sans serifs was also adopted for the translations. The estimated font size of 10.5 points with an estimated line spacing of 1 in the source text was increased to 14 points (Bundesministerium für Arbeit und Soziales, 2014) with a line spacing of 1.5 in the translated texts. Important terms were already marked in bold in the standard texts. In the translated texts, further technical and foreign terms were printed in bold as well as terms that were subsequently explained in the direction of reading. The decision about which terms are newly introduced or are important is derived from the (school) curricula and personal teaching experience or, as a teacher, knowledge about the competences of the students.

Additional images were not included in the translations as the research project focuses only on textual features. Nevertheless, the position of the images was adjusted by placing them thematically appropriate next to the corresponding text content. Many of the illustrations were enlarged to achieve a larger font size within the illustrations.

Regarding the character level, only the following characters were used in the translations as per the rules: full stops or question marks, colons, bullet points for enumerations and the mediopoint within long terms. Numbers were written out as digits.

Translations adhere to the basic principles of Easy Language, including the following:

The distribution of grammatical functions to several elements in the sentence; for example, in the genitive case, instead of 'Schädel eines Maulwurfs' (= 'skull of a mole'), 'Schädel von einem Maulwurf' is used.

The orientation of sentences to actions is realised by using, for example, fewer nominalizations and making actors explicit as in 'Die lange Kralle nennen wir: Sichel·bein' (= We call the long claw: pre·pollex) instead of "Sie wird Sichelbein genannt" (Bergau et al., 2012: 49; = 'It is called prepollex').

The compliance with the chronological description of actions in the source text to maintain the bridging function.

The use of correct spelling and grammar.

The use of central categories in the form of, for example, everyday terms. With the help of the online German dictionary 'Duden', more commonly used words could be found, e. g., 'finden' (= to find) instead of 'orientieren' (= to orientate).

The use of everyday terms was not consistently implemented in the translated texts, particularly when dealing with technical terms. In the translated texts, it was decided in advance to retain technical terms due to the following reasons: 1.) to ensure or at least enable the acquisition of competences in the area of technical language (as required by the educational standards), 2.) to maintain the precision required in technical language and the field of sciences (Schroetter-Brauss et al., 2018) and 3.) to avoid paraphrasing by using different synonyms. When technical terms were retained, they were explained according to the rules of Easy Language by indenting the explanations and making them appear in the direction of reading.

The principle of redundancy was enforced by, for example, repeating the explicit naming of the actors (use of 'mole' instead of the personal pronoun 'it').

At the word level, abbreviations such as 'cm' were directly explained by spelling them out as in 'Zenti·meter' ('centi·metre'). Also, an attempt was made to comply with the requirement for short words. This proved to be difficult with some compounds as they often also represented technical terms that were to be maintained in the translations. To simplify the perceptibility, the mediopoint was used when retaining compounds. In doing so, word boundaries within a word were highlighted to simplify the recognition of the word components. While the use of the mediopoint for compounds was reasonably objective, for other longer words, for which no shorter alternatives could be found, it was difficult to decide which prefixes/suffixes should be highlighted by the mediopoint and which should not. The rules do not provide any detailed guidelines concerning those characteristics. In the translations used in the study, prefixes and suffixes were emphasised using the mediopoint to highlight the root within a word (Bredel & Maaß, 2016b), such as in 'ver·zweig·ten' (= branch·ed) or 'an·ge·passt·en' ('passt' = fit).

Metonymy or borrowings from everyday language were not found in the standard texts. Metaphors, such as 'unter Tage' (an old German expression for 'underground' referring to mining), were avoided as they cannot be understood with the help of the students' everyday context knowledge. Synonyms were also avoided by constantly using the same terms (also by using technical terms) for the same concepts. On the word level, the genitive was also eliminated. Subjunctive forms were not found in the source texts. Avoiding nominalizations through the increased use of the verbal form proved to be difficult; thus,

in most cases, abstract nominalizations, e. g., 'Nahrung' (= 'nutrition'), were explained in the direction of reading.

At the sentence level, condensed information within one sentence in the source text was spread over several sentences in the translated text. In this way, it was possible to resolve attributes such as "Ihr etwa 15 cm langer Körper ist walzenförmig" (Bergau et al., 2012: 49) (= 'Their roughly 15 cm long body is cylindrical') in the standard text, translating it, for example, into the following:

'Der Körper von dem Maul·wurf ist etwa 15 cm lang. cm bedeutet: Zenti·meter. 15 cm sind so lang wie ein kleines Lineal. Der Körper ist walzen·förmig. Walzen·förmig bedeutet: wie eine Rolle.' (= 'The body of the mole is about 15 cm long. cm means: centi·metre. 15 cm is as long as a small ruler. The body is cylindrical. Cylindrical means: like a roll.')

Additionally, the sentence structure 'subject, verb and object' (S-V-O) could be implemented well. As such, separate verb structures were joined or replaced by other verbs, e. g., "In besonderen Kammern legt der Maulwurf Vorräte für den Winter an" (Bergau et al., 2012: 49) (= 'In special chambers the mole stores supplies for the winter'), becoming 'Der Maul·wurf sammelt **Vorräte** für den Winter' (= 'The mole collects supplies for the winter'). When it was not possible to join the prefix of a verb to the verb stem, it was printed in bold letters to prevent the meaning-bearing prefix from being read over at the end of a sentence. Furthermore, subordinate clause structures were dissolved by splitting the information into several consecutive main clauses and/or applying rules of Easy Language. When resolving subordinate clause structures and replacing connectors in the source texts, connectors permitted by the rules, including 'deshalb' (= therefore), were used consistently. Passive structures, as indicated previously, could be avoided by concisely naming action carriers. The tense in the source text did not have to be adapted in the translations because the texts did not include any past/future tenses. The negation was mostly implemented using the negation marker 'nicht' (= 'not') in bold print. Sometimes, the negation marker 'nicht' could not be used. In these cases, the negation by 'keine' (= none) was at least emphasised more clearly using the bold print. Prepositions were handled similarly because no translation strategies according to Maaß (2015a) are available for them.

At the text level, all information from the source texts was retained to give all students equal access to them. The requirements of the educational standards and the (school) curriculum contributed significantly to this decision. Personal pronouns were replaced by concretely naming the subjects and objects. Possessive pronouns were retained. The structure of the source texts was also adopted in the translations such that subheadings also exist in the translated texts.

6.3 Compliance with Educational Standards

Regarding the competences that pupils are expected to acquire successively from the fifth grade on, the 'use of biological terms in the correct context' (NKM, 2015) is stimulated by

retaining technical terms in the translations. In principle, the basic concepts could be addressed equally in terms of content both in the standard texts and the translations. This section briefly describes the realisation of the basic concepts.

Unsurprisingly, the category 'explaining adaptations of living organisms to season and habitat' was ascribed the most codes as the adaptations of six animals to their habitat was the central topic of the texts. Similarly, the category 'explaining the relationship between the structure and function of organs' was coded extensively. A strong correlation could be recognised here since in all texts, different body characteristics such as adaptations of the animals to their habitat and/or to certain seasons are thematized. Strikingly, in some cases, both in the standard and therefore in the translated texts, the mention of structures, here body features, remains without a description of their function.

The category 'naming of selected animal species in their habitat' was coded six times in total since each of the six texts describes an animal species in its specific habitat.

The communication of animals with species-specific signals and the thematization of selected organs in the context of their interaction with other organs in an organism are less-central topics. Nevertheless, species-specific communication is mentioned in the text on woodpeckers. In the texts on woodpeckers and bats, the connection of different structures within an organism is at least hinted at. In the text on woodpeckers, it is explained how spongy bones and strong cranial muscles protect the woodpecker's brain when pecking. In the text on bats, the function of the body fat for the bat's survival in winter is described.

In all texts, the competence 'representing direct food relationships' can be addressed at least in the form of food chains (but not nets).

The competence 'describing the characteristics of the living' can be addressed by the texts, but it is typically included in the first topic in the fifth grade, relating to the topic of keeping domestic and farm animals.

Linguistically, the basic concepts are implemented differently in the Easy Language texts compared to the source texts. This is particularly noticeable in the concept of 'structure and function'. In the source texts, both structure and function as adaptations to the habitat are often mentioned within one sentence. In the translated texts, this is often done in separate sentences due to inserted explanations such as the following:

'Der Biber hat Schwimm·häute zwischen den Zehen von seinen Hinter·beinen. Schwimm·häute bedeutet: Haut zwischen den Zehen. Die Schwimm·häute helfen dem Biber beim Schwimmen.' (= 'The beaver has webbed feet on its hind legs. Webbed means: skin between the toes. The webs help the beaver to swim.')

However, the connections between structures within an organism become clearer by implementing additional explanations in some translated texts. An example of this is the more comprehensive explanation of the use of bats' fat reserves as a source of energy to survive the season of winter. These assessments could be validated within the described study with the help of interviews with teachers (Schaller, n. d.).

7. Discussion

Compared to the few existing analyses of scientific school textbooks (e. g., Schmellentin et al., 2017; Graf & Berck, 1993), as expected, numerous possible comprehensibility barriers were identified for the examined biology texts in this study. As such, this analysis provides precise insight into the number and multiple assignments of possible technical language barriers.

This study also analyses in detail the extent to which texts from biology textbooks can be translated into accessible language. Overall, translations into Easy Language were possible, which was assumed based on Maaß's take on school subject didactics about evaluating the use of Easy Language in the school context (2015b). Easy to implement was, for example, enlisting enumerations via key points and avoiding synonyms and forms of references by consistently giving an object the same name throughout the texts. However, regarding selected rules, questions remain. Concerning the segmentation of long words, translations felt more subjective due to missing concrete hints at segmentation boundaries by the given rules: are only lexical segments separated or flectional elements also? (for discussions see e. g., Bredel & Maaß, 2016b). Another point of discussion is the handling of technical terms in the translations: leaving them out, as recommended by the rules, would decrease the possibility of growth in language competences defined by educational standards. At the same time, it would be helpful to keep and constantly refer to them to avoid synonyms. Furthermore, the translations' length can be problematic. However, in terms of target-oriented and stigma-free teaching, it would be critical if content were to be deleted from the translations. Schaller et al. (2019) found that although the translated texts become longer, they are still preferred by students.

Concerning correspondences between the possible comprehensibility barriers in biology textbooks and rules of Easy Language (Table 1), another question remains: how can and should possible language barriers be dealt with, for which there are no suggestions for modification according to the rule book for Easy Language, including prepositions and functional verb structures? Here, (combinations of) different language-sensitive concept(s) could provide help, e. g. models for improving reading and writing skills like SPRAAK (Michalak et al., 2015), 3-phase model (Schmölzer-Eibinger & Langer, 2010) or scaffolding (Gibbons, 2015), of which the latter concept even allows the integration of language-simplified texts as supportive 'scaffolds'. There are also small language-supporting methods that can be applied quickly within a school lesson, such as word lists, sentence construction kits and more (e. g., Beese et al., 2017; Leisen 2017; Weis, 2013). In this regard, reference should be made to the new edition (Dolpp et al., 2020) of the analysed school book in the described study. In the new edition, for example, individual terms in the continuous text are underlined and explained next to the text. Other textbook publishers also integrate word lists at the end of chapters or of the entire book. Some also use mnemonic boxes to summarise the most important text content. Furthermore, tasks are set at differentiated levels and important terms are highlighted in bold. In addition, supplementary materials are offered for differentiation. For example, one publisher offers

materials for language support for pupils with German as a second language ('Prima ankommen'; e. g., Cakir-Dikkaya, 2017). Another publisher (e. g., Adesokan et al., 2017) also offers such material, in which extra explanations are provided in the margins of the text or the first language can be used. Another publisher (e. g., Grauer, Haas, Lüchtefeld, Schaper, Seeger, Tretter & Walter, 2017), on the other hand, offers materials for pupils with special educational needs in which texts are written in simple language, which is characterised, for example, by a large sans serif font and short sentences. A uniform use of simplified language according to certain rules cannot be observed so far, although some of the rules of Easy Language are partly used in the mentioned textbooks. The evaluation of the integrated language aids is also pending, at least in parts.

Some of the specified competences within the framework of the educational standards can be theoretically developed through both the original school book and the translated texts. However, they are presented differently in the two text variants. Regarding statistical results, studies on the use of simplified language have thus far demonstrated contradictory results on its effect on, e. g., content-related competences (Brown & Ryoo, 2008; Härtig et al., 2019; Schneider, Dittmar, Gilg & Schmellentin, 2018; Thun, Göbel & Tausch, 1973).

Furthermore, the static and normative character of Easy Language is also criticised (e. g., Erhardt & Grüber, 2011). What is meant here is that due to the lack of different levels of language complexity within the concept, Easy Language does not contribute to the further development of the pupils' language skills. It is precisely because of this lack of different levels of language complexity that critics say that it is not possible to address individual language problems with just one more language variant, and that some pupils can still be overstrained even with Easy Language. Implementing and evaluating different simplifying language variants in subjects also other than biology can open up possibilities for these points of criticism and answer questions concerning the translation process. In this regard, suggestions are already in place, including language variants that gradually increase in difficulty (e. g., Maaß, 2020; Baumert, 2016), which can contribute to a differentiation according to different language levels and impairments.

The results of this study can contribute to the conception of school books, especially since parts of Easy Language already find their way into them. Concepts of Easy Language can thus be internationally considered for the use in the school context as texts for biology classes bear similar barriers to comprehensibility in many languages. For example, in English, students also have problems with nominalizations, prepositions, attributions, subordinate clauses and impersonal expressions (e. g. Fang, 2007). When these texts are translated into an easier language, there will certainly be similar questions due to the resulting length of the translated texts, for instance.

In summary, it can be said that Easy Language is applicable to biological school books and can theoretically reduce text comprehensibility barriers by modifying them. The question remains, however, to what extent Easy Language really supports students, especially in the context of a high level of heterogeneity in the classrooms and the existing critics. A current study at the University of Vechta, in which the increase in knowledge of

students and the attitudes of teachers regarding the use of Easy Language are being evaluated, should provide further information on this in the near future (e. g., Schaller et al., 2019). Furthermore, the question remains to what extent the concept can be effectively integrated into already existing support concepts of language-sensitive subject teaching (such as scaffolding), or whether the concept is more/less supportive than already existing more offensive language-sensitive methods or current school book developments.

Especially in biology lessons, the question remains to what extent texts are an appropriate medium to teach cognitively and linguistically challenging topics, especially when other typical biological methods could be used instead, such as experimenting, observing living animals etc. The fact that the evaluation of texts in biology lessons is nevertheless still interesting is proven by the continued actual use of textbooks, e. g. during independent acquisition phases on the part of the students. (e. g., Beerenwinkel & Gräsel, 2005; Kölker, 2015).

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