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in the Austrian CLIL biology classroom

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I. Introduction

Communication among scientists through research papers has become increasingly anglicized throughout the whole world in the last decades. Since one goal of secondary schools is to prepare their students for tertiary education, this linguistic change towards using the English language for all academic purposes also influences the demands for secondary schools. The skill to read scientific literature in English is even present in the curriculum for biology and environmental science for Austrian upper secondary schools (Lehrplan 2004: 2). The teaching of reading scientific texts is also very suitable for Content and Language Integrated Learning (CLIL), since the content of the article and the genre-specific text features are both important for text comprehension. To scaffold the learning of reading scientific texts, a research field has been developed focusing on adaptations of scientific literature for educational purposes: Adapted Primary Literature (APL). This study sets out to combine the research field around APL, which originated within science education, and the field of linguistic modification and connect the suggestions put forward by the literature with the demands of a quality CLIL classroom in an Austrian setting.

The thesis begins with presenting an overall picture of CLIL and its Austrian implementations. Additionally, a matrix for teachers who want to offer quality CLIL education written by the Austrian center for language competence (Österreichisches Sprachen-Kompetenz-Zentrum) is consulted to show the huge amount of overlaps of the goals of APL and CLIL, which supports the use of Adapted Primary Literature in the biology CLIL classroom. Chapter 3 focuses on different approaches to the skill of reading which are important for secondary education. The influences of prior knowledge and interest on reading comprehension are also topic in this section. As a transition towards science education, the concept of scientific literacy is discussed, followed by a detailed description of Primary Scientific Literature (PSL) and the research article through the lens of the genre-approach. PSL is the source material for the adaptations and a thorough depiction of the genre is necessary, since the features discussed in this section will be subject to adaptation, following the approaches of Adapted Primary Literature and linguistic modification in chapter 6. The historical overview of the research on APL and comparisons with related genres lead to the conclusion to use the fairly new concept of Hybrid Adapted Primary Literature (HAPL), which differs from APL only through minor additions. The theory collected in chapter 6 is arranged into a guideline which includes criteria for selecting an appropriate research article and seven steps of adaptation.

The empirical part of this thesis consists of a study executed in two eighth grades in the BRG 14 Linzerstraße. After describing the circumstances of the study, the guideline created in chapter 7 is applied to a PSL text which serves as the basis for the empirical study. The participants were divided into two groups, one read the original PSL text and the other group received the HAPL text, adapted after the guideline of the theoretical part of this thesis. After exemplifying the steps of adaptation, the literature behind the design of the data collection is presented. The data collected consists of a reading comprehension test and questionnaires concerning the different topics mentioned in the theoretical part. First the different types of reading comprehension and their differences regarding the genres are analyzed, and following this, the questionnaires are assessed quantitatively and then qualitatively.

In summary, this thesis combines theory on APL and linguistic modification and sets them in the context of CLIL. Through connecting the approaches of science education and language learning, especially reading, a new adaptation framework has been created, tailored to the Austrian CLIL classroom. The adaptation guideline is consequently applied to Pascher (2016) and the differences in reading comprehension are studied in the empirical part.

II. Theoretical framework

1. CLIL

The term *Content-and-Language-Integrated-Learning* can be seen as an umbrella term for several different educational approaches (Dalton-Puffer & Smit 2007: 8), such as *Content-based Instruction* (CBI), *Bilingual Integration of Languages and Disciplines* (BILD), *Foreign Languages Across the Curriculum* (FLAC) (www.content-english.org), just to mention a few. The common notion of all these terms is that a “language other than the students’ mother tongue is used as medium of instruction” (Dalton-Puffer 2007: 1). While the different terms all have valid philosophies underlying them, CLIL has become the most established term in Europe (Dalton-Puffer 2007: 1). The growing importance of the concept of CLIL in Europe can be traced back to the internationalization and globalization processes of the last decades, which have been supported by institutions like the European Union and the Council of Europe (Dalton-Puffer 2007: 1). Despite the numerous approaches to CLIL, commonalities can be found in programs all over Europe (Dalton-Puffer & Smit 2007: 8). For example, the notion of using natural language in the classroom through integrating so-called content subjects to foster ‘real communication’ (Dalton-Puffer 2007: 3). Learning about biology through the English language adds a purpose and meaning to language teaching, which is often missing in language classes

but is important for the teaching approach of *Communicative Language Teaching*, i.e. the most common approach in today's Europe (Dalton-Puffer 2007: 3). In 1995, the European Union published *Teaching and Learning: Towards the Learning Society* which described some of the EUs language policy goals, for example to foster plurilingualism. (Unterberger 2008: 14). The goal of plurilingualism should also be fostered in mainstream education and be promoted through secondary school students' studying of a subject, not in the mother tongue, but in their first foreign language (European Commission 1995: 47). Fostering plurilingualism through CLIL has been mentioned in later publications by the Council of Europe as well and has led to a widespread implementation of different CLIL programs within the EU (Unterberger 2008: 15). In fact, throughout whole Europe there are only four countries that do not offer CLIL-programs (by 2012), namely Denmark, Greece, Iceland and Turkey (Eurydice 2012: 10). One focus of research of CLIL has been the integration of subject and language teaching. This is also an important aspect of this thesis since it adds to the existing knowledge on "developing integrated subject- and language-related tasks" (de Graaf 2016: xv). As mentioned in the next chapter, Hybrid Adapted Primary Literature attempts to achieve exactly that, integrating subject- and language learning in one text.

Since the empirical study of this paper is executed in a Viennese school, the terminological issues of the Austrian school system will be discussed briefly. CLIL is often mentioned only in context with the English language, nevertheless, there are other languages, such as Slovene, or Hungarian employed for CLIL teaching in Austria as well (Eurydice 2005: 5). There are four terms closely linked to the concept of CLIL in use in the Austrian education system (Eurydice 2005: 3f). Firstly EAA (Englisch als Arbeitssprache), which is widely used but the implementations vary considerably (Unterberger 2008: 8). The common feature of this label is that English is not used exclusively but shares the spot of language of instruction with German (Mewald et al 2004: 57-8). According to Mewald et al (2004: 42), the best way to teach EAA is through team-teaching, in which case one teacher is the subject teacher and the other teacher the language teacher. A different acronym is EAC, *English Across the Curriculum*, which differs from EAA through its focus on cross-curricular networking of several subjects and the essential standing of intercultural understanding (Eurydice 2005: 3). In Austria the term *English as a Medium of Instruction* is typically used for tertiary education (Eurydice 2005: 3). The language policies concerning the university level are very complex and will not be discussed in this thesis. In contrast to EMI, the last acronym mentioned by Eurydice (2005) is rather important for this thesis. LAC, *Language Across the Curriculum*, can be seen as an international equivalent of EAC (Mewald et al 2004: 5). In the Eurydice report (2004), the *Dual Language*

Programs (DLP) offered by many Viennese schools are categorized into LAC. This categorization is misleading, since the separation of the two languages of instruction is a key feature of dual language programs (Torres-Guzmán 2007: 52), while the LAC approach tries to connect all subjects. Therefore, the name of Viennese DLPs is misleading, since they resemble the definition of EAC/LAC more than that of *Dual Language Program* (Unterberger 2008: 9). The terminology of the language programs is important for this thesis, since the empirical part has been conducted in an *Vienna DLP* setting rather than an *DLP* setting. Unterberger (2008: 9) created a table to illustrate the difference of the two terms:

Table 1: Comparison of DLP & VDLP (Unterberger 2008: 9)

<i>Dual Language Programs</i>	<i>Vienna Dual Language Programme (EAC / LAC)</i>
Aim: Raise status of minority language	Aim: Increase students' exposure to first foreign language, i.e. English ⁵
Equality in language distribution	Predominant Language of Instruction remains German as not all subjects are taught bilingually - English exposure is increased
Avoidance of simultaneous translation	Technical vocabulary is translated into German; Students' code-switching is allowed to reduce anxiety
Strict language separation	DLP lessons are usually divided into German and English parts ⁶

When it comes to the conceptualizations of CLIL implemented in the DLP classroom, Coyle (1999) proposes the 4Cs framework. The 4Cs which should frame every CLIL teaching include communication, cognition, content and culture. Communication in this context not only refers to linguistic elements like grammar, but bigger concepts such as codeswitching and language choice (Coyle 2007: 552). Zydatið (2007: 16) puts communication in the center of his framework, whereas Coyle (2007: 551) uses culture as the central influencing aspect. In sociocultural philosophy, CLIL is based on cultural competence as understanding “social awareness of self and ‘otherness’” (Coyle 2007: 550) and intercultural learning impact all thinking (cognition), communicating and construction of knowledge (content) (Coyle 2007: 552). As Coyle, Hood & Marsh (2010: 64) put it: “Integrating cultural opportunities into the CLIL classroom is not an option, it is a necessity”. The implications can affect different aspects of CLIL teaching, for example through the content, classroom ethos, or ways of linking the curriculum (Coyle et al 2010: 64). Concerning the connections of cognitive level and language

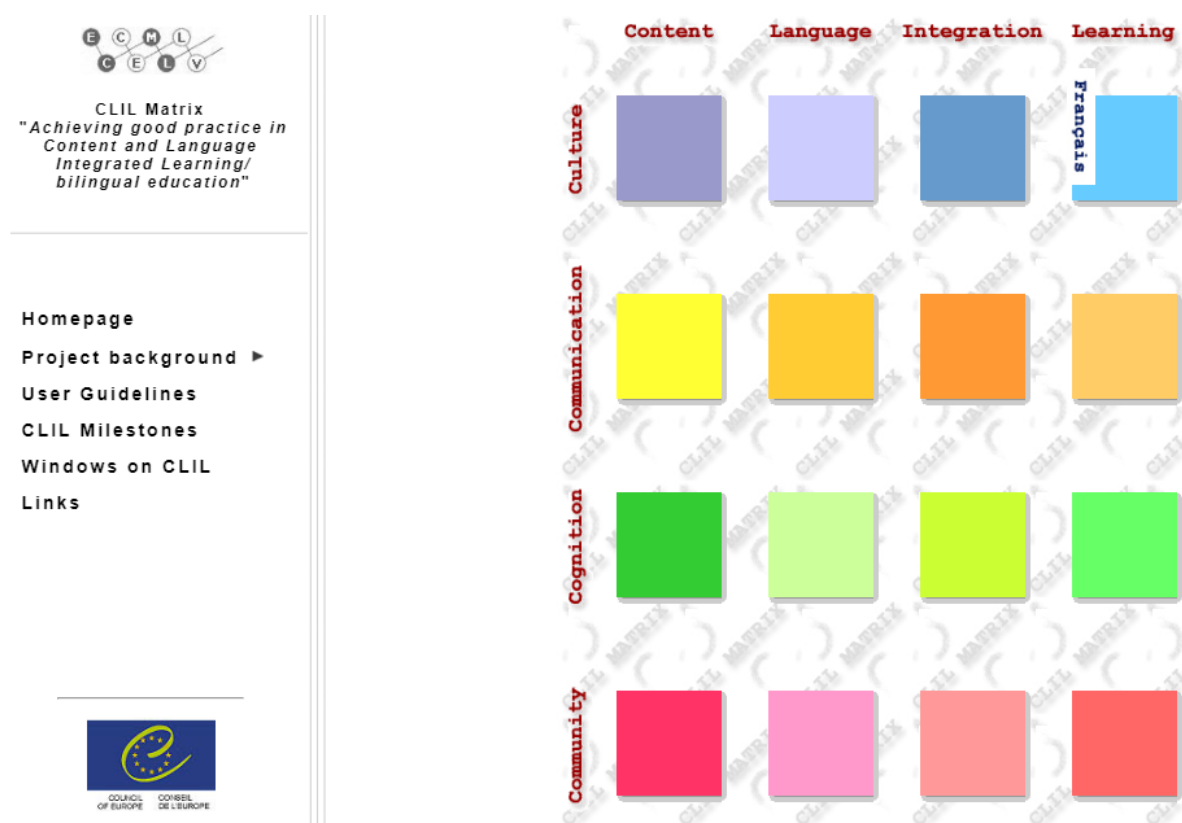
level, Coyle et al (2010: 43) propose the CLIL matrix which tries to explain learning restrictions due to mismatches of linguistic and cognitive demands. Low cognitive demand hinders students' engagement and learning, while too much linguistic demand also prevents effective learning (Coyle et al 2010: 43). APL is a way to balance these two aspects of learning.

Coyle (2007: 553-555) also mentions three connections of language and learning. Firstly, *language of learning* stresses the importance that the language level should suffice for accessing the topic. This can be scaffolded through content, for example through authentic text (Coyle 2007: 553). *Language for learning* addresses the importance of meta-skills of learning, i.e. learning how to learn. For example, for effective group work one has to be able to communicate with several speech partners at the same time, including turn-taking etc. Lastly, *language through learning* stresses the sociocultural background of CLIL. No learning can take place without active thinking and language use which are based on one's culture.

2. Combining the CLIL-matrix with goals of APL

When it comes to publications supporting the use of CLIL in the Austrian school system, the ÖSZ (Österreichisches Sprachen-Kompetenz-Zentrum) has created a 16-item matrix which should foster active reflections of teachers' CLIL lessons and helps identify room for improvement (Gierlinger et al 2010: 9). They used a combination of Coyle's (2007) 4Cs framework and the four terms embedded in CLIL, i.e. Content, Language, Integration, and Learning, to present a matrix with 16 indicators. These indicators of good CLIL practice are joined by questions to reflect on one's own competences and applications of those indicators in one's own teaching. The following screenshot shows the matrix. The further information provided, like reflective questions and descriptions of the indicators are provided only if one clicks on one of the 16 colored squares. The x-axis consists of the categories Content, Language, Integration and Learning, and the y-axis of Community, Cognition, Communication and Culture.

Table 2: CLIL Matrix screenshot (<http://archive.ecml.at/mtp2/clilmatrix/en/qmain.html>) (04.10.2018))



The screenshot displays the CLIL Matrix interface. On the left, there is a navigation menu with the following items: **Homepage**, **Project background** (with a right-pointing arrow), **User Guidelines**, **CLIL Milestones**, **Windows on CLIL**, and **Links**. Below the menu is the logo of the Council of Europe, featuring a stylized 'e' and the text 'COUNCIL OF EUROPE' and 'CONSEIL DE L'EUROPE'. The main part of the screenshot is a 4x4 grid of colored squares. The columns are labeled at the top: **Content**, **Language**, **Integration**, and **Learning**. The rows are labeled on the left: **Culture**, **Communication**, **Cognition**, and **Community**. Each square in the grid is a different color, representing the intersection of the row and column concepts. The colors are: Culture-Content (purple), Culture-Language (light purple), Culture-Integration (blue), Culture-Learning (light blue); Communication-Content (yellow), Communication-Language (orange), Communication-Integration (dark orange), Communication-Learning (light orange); Cognition-Content (green), Cognition-Language (light green), Cognition-Integration (yellow-green), Cognition-Learning (bright green); Community-Content (pink), Community-Language (light pink), Community-Integration (light red), Community-Learning (red).

	Content	Language	Integration	Learning
Culture				
Communication				
Cognition				
Community				

When it comes to the indicators concerning cultural aspects of the CLIL framework, the matrix states that “[c]ulture is deeply embedded in many aspects of communication” (CLIL matrix – content/culture). Therefore, appropriate target language input through materials is necessary (CLIL matrix – content/culture). The cultural aspects of teaching PSL or HAPL could be identified as the cultural characteristics of scientific communication and the construction of scientific knowledge. The depiction of the findings not as absolute truth, but as new information with implications open for debate is an important aspect of the communication and culture among the scientific discourse community. The intersection of language and culture in a quality CLIL classroom happens through giving the students the possibility to “acquire and use a broad range of registers in the target language” (CLIL matrix language/culture). The register of scientific communication certainly fosters this goal of CLIL teaching. Integrating culturally relevant language and content and clearly specifying the wider cultural objectives is, according to the CLIL matrix, essential for quality CLIL lessons. One cultural objective of APL and HAPL and the use of other more or less authentic scientific texts in the biology curriculum is to provide “both a simulation and an opportunity for participation in a scientific practice in the classroom, thus enabling enculturation of students into an authentic scientific experience” (Yarden et al 2015: 27). This notion also goes in line with the feature of quality CLIL described

in the CLIL matrix as the combination of culture and learning in which the importance of intercultural learning and “studying a topic through an alternative perspective” (CLIL matrix culture/learning). The perspective from which the students view the topic is the one of a scientist, who researched and wrote within the traditions of the culture of scientific knowledge production.

The intersections of communication and the four aspects of CLIL include the combination of communication and content, which is defined in the CLIL-matrix mainly as “interactive learning” (CLIL-matrix communication/content). The CLIL-matrix exemplifies interactive learning with pair and group work, however the amount and use of these methods depend highly on the teaching approach one chooses for teaching the reading of scientific texts, such as Adapted Primary Literature. Yarden et al (2015: 96-101) mention three different instructional approaches: the conversational approach, the problem-solving approach and the scientific literacy approach.

When using the conversational approach students only read the article part by part and the teacher scaffolds the students’ understanding through comments, questions and additionally prompts students to ask questions themselves (Yarden & Falk 2011: 79). The interaction happens mainly through teacher-student talk, but steps like group discussions are also part of Yarden et al’s (2015: 97) suggestions. The interaction, when using the conversational approach, occurs not only between students and teachers, but also with the APL text itself. According to Yarden et al (2015: 96) the “students conduct a “conversation” with the article, rather than read it individually”. When teaching APL through the conversational approach, students have to read the APL article together and engage in discussions after each section. By helping each other understanding the article and debating the implications of the research presented in the article, the inquiry aspect of science teaching is highlighted.

The problem-solving approach includes exposing the students to the problem the article tries to answer, and through interaction with each other, the students should come up with possible solutions. This may lead to a similar experimental approach as the APL article. The problem-solving approach also demands a large amount of interaction, as students have to come up with a possible solution together through discussing different options with the guidance of the teacher.

Less clearly defined is the interaction needed for the scientific literacy approach. The different genres of scientific texts, described at a later stage in chapter 6.1, are presented to the students

to highlight the different aspects of scientific communication (Yarden et al 2015: 101). How the comparison of the genres combines communication with content is not stated in Yarden et al (2015). Although the amount of communication when teaching APL is dependent on the instructional approach, communicative tasks can help scaffolding the content of the article.

Quality CLIL education combines language and communication in that “the teacher’s communication should ensure maximum richness of language while adapting to the learner’s level” (CLIL matrix language/communication). If one sees the input provided by the teacher as the teacher’s communication, APL fits this description exactly. Since the “APL genre, which retains the characteristics of PSL while adapting its contents to the comprehension level of school students” is combined with linguistic modification, through which “a piece of discourse is reduced to a version written in the supposed interlanguage of the learner” (Widdowson 1980: 185), the inclusion of teaching APL is perfectly in line with the language and communication aspects of a quality CLIL class. The importance of “diverse types of communication when learning content” is stressed when the combination of integration and communication is described in the CLIL matrix. Since APL diversifies the canon of genres typically used in educational settings, i.e. textbook texts and newspaper articles, this indicator of the matrix also supports the use of APL in CLIL teaching.

The last indicator focusing on communication is its intersection with learning. “[T]o actively support both the language and the content learning”, quality CLIL should demand “a wide variety of communication skills” (CLIL matrix learning/communication). Again, this indicator is highly dependent on the instructional approach used by the CLIL teacher, described earlier.

When it comes the C of cognition, both the APL research summarized by Yarden et al (2015) and the input modification theory address the reduction of the cognitive demands resulting from reading a scientific text. Concerning the intersection of cognition and content, the chapter on content modification discusses methods that “nurture the cognitive demands resulting from CLIL” (CLIL matrix content/cognition). The cognitive demands of reading APL are discussed mainly in the section on syntactic simplification. Other ways of guiding and supporting students in building up concepts in the target language (CLIL matrix language/content) are the reduction of jargon, as discussed in the lexical modification section. This was studied by McDonnell et al (2016) who develop a ‘concepts first – jargon second’ approach which improved students’ understanding of new concepts.

Regarding the correlations of integration and cognition, the matrix mentions that all CLIL teachers “should constantly carry responsibility for the cognitive demands of dealing with both language and content” (CLIL-matrix integration/cognition). The linguistic cognitive demands of a scientific article are described in later chapters.

A similar aspect of quality CLIL teaching is stated concerning the intersection of learning and cognition. Balancing the cognitive demands of the subject and the language through appropriate methods (CLIL matrix learning/cognition) has to be considered when teaching APL as well. If one just simplifies a PSL article linguistically, the students might still be unable to understand the experiments and concepts behind the article. On the other hand, if one solely focuses on elaborating and breaking down the content, while still using a huge amount of academic and scientific lexis, the students will probably be unable to comprehend the text as well. The last four indicators do not combine ‘content’, the last of the four Cs with the single aspects of CLIL, since it is already present as one of the latter (Content, Language, Integration, Learning). Instead the authors of the CLIL matrix chose to foreground the importance of the ‘community’ in which CLIL takes place, including “the school parents and other stakeholders” (CLIL-matrix content/community). The matrix mentions that a positive atmosphere within the school and the recognition of the value of CLIL teaching by the wider society is important for quality CLIL (CLIL-matrix content/community CLIL-matrix integration/community, CLIL-matrix language/community, CLIL-matrix learning/community).

Concerning reading in CLIL, Harmer (1983: 146) differentiates between educational texts which are explicitly composed for language learners to practice reading, and genuine texts with the sole purpose of communication. Windhager (2014) studied the distribution of the four skills (writing, speaking, listening and reading) during CLIL teaching in Austria. Her results show that the lessons she observed contained a mere one percent of reading, while listening and speaking dominated the CLIL lessons (Windhager 2014: 83). A more general approach to reading will be discussed in the next chapter.

3. Reading

Starting with a short historical overview, this section will cover theory on reading that is concerned with CLIL and science teaching, connecting this skill with the concepts of prior knowledge and interest. Usó-Juan & Martinez-Flor (2006: 262) start their historical overview of research about reading with the time before the 1960s in which reading was seen as a solely passive and perceptive skill. This influenced the teaching of reading in that it focused on

decoding skills (Usó-Juan & Martinez-Flor 2006: 263). In the 1960s, the notion of reading as an innate skill which can only be learned through practicing reading emerged (Usó-Juan & Martinez-Flor 2006: 263). This approach changed teaching through placing the reader in an active position, where the readers have to “derive meaning from the text by predicting and guessing its meaning by using both their knowledge of language and their background” (Usó-Juan & Martinez-Flor 2006: 264). By the late 1970s, contributions from disciplines like cognitive psychology and sociolinguistics led to various new concepts of reading which Usó-Juan & Martinez-Flor (2006: 264-6) summarize under the term interactionist approach. The interaction refers to the writer and reader, who create “meaning from the text by activating [their] stored knowledge and extending it with the new information supplied by the text” (Usó-Juan & Martinez-Flor 2006: 265). Another innovation was the expansion of the term context from the immediate surrounding words to a “larger social context with its values, beliefs and norms” (Usó-Juan & Martinez-Flor 2006: 266).

Another aspect of reading is the differentiation of bottom-up versus top-down processes. Hellekjær (2009: 200) summarizes bottom-up processes as “recognizing the written words in the text along with grammatical information”, and top-down processes include “the creation of meaning in an interactive process between the information in the text being read, the reader’s knowledge of the language and content, and his or her processing skills and strategies” (Hellekjær 2009: 200). Some factors can influence the reading skill and the performance on reading comprehension tests as well. Two of these influential factors, prior knowledge and interest will be discussed in the following paragraphs.

The relation between reading comprehension and topic interest, concerning language learners has been subject of many studies and seems to be widely accepted as being a positive relationship, meaning that students’ interest in a topic fosters reading comprehension (Baldwin et al 1985: 498). Nevertheless, this relation can also be of negative nature, if there is an “ability-difficulty mismatch” (Ardasheva & Tretter 2018: 631). If the text’s difficulty level exceeds the students’ reading skills, comprehension decreases and this can impair the students’ interest in science (Ardasheva & Tretter 2018: 631). Additionally, there are controversial positions on whether interest itself is the variable increasing comprehension, or if interest is highly correlated with prior knowledge, which would then be the main factor fostering reading comprehension (Baldwin et al 1985: 498). Baldwin et al (1985: 502) discovered that, in children, these two factors are separate, but as people get older and their interests get more specialized the

correlation between knowledge and interest grows stronger. Before discussing the interaction of the two concepts, one has to look at the complexity of these multidimensional factors.

Prior knowledge is often addressed with synonyms such as subject-matter knowledge (Alexander et al 1994a) or background knowledge (Windhager 2014: 62). Windhager (2014: 63) describes background knowledge as “an umbrella term for all types of knowledge such as sociocultural, genre, topic, or general world knowledge”. Alexander et al (1994a) propose a division of subject-matter knowledge into topic knowledge and domain knowledge (Alexander et al 1994a: 314). While topic knowledge refers to a more specified type of knowledge, in our case the topic of genetically modified organisms, the term domain knowledge encompasses a broader field of study (Alexander et al 1994a: 314), e.g. biotechnology, or ecology. These distinctions are mentioned later again, since they have been incorporated into the questionnaire used in the empirical part (see chapter 9.3). Alexander et al (1994a: 325) discovered that domain knowledge is directly correlated with recall, which means that the more students knew about the field, the more they remembered from the text they read. Additionally, they found out that if someone has more field-specific knowledge, one is more interested in reading scientific expositions. Nevertheless, a different study by Alexander et al (1994b: 390) shows that, in reading comprehension tests, one can make up for lacking topic knowledge with text processing skills and domain knowledge. When it comes to prior knowledge in terms of prior language skills, a study by Ardasheva & Tretter (2018: 637) shows that lower English proficiency is correlated with low reading comprehension scores of science texts and with low interest in science. Alexander et al's (1994b: 391) results agree with these findings in that, while being rather small, there are positive effects of interest towards recall.

The influence of prior knowledge is not the only influence on reading that has been studied extensively. The multifaceted term ‘interest’ needs to be addressed here as well. Alexander et al (1994a: 315) subdivide this broad term as well, into situational interest and individual interest. Situational interest describes the short-lived form of attention or arousal that momentarily arises through themes such as sex, death or danger (Alexander et al 1994a: 315). A longer and more deep-seated form of interest is individual interest, which describes a profound involvement in a subject or topic which evolves over months and years. Ardasheva et al (2018: 631-632) modify these terms into ‘triggered situational interest’, which are elicited through the text and its characteristics, and ‘well-developed individual interest’, which is traditionally seen as the more important type of interest. Renninger (2000: 374) mentions that individual interest is “the kind of involvement teachers love to see in their students”. Alexander

et al's (1994a: 334) findings, for example, support the need for enhancing students' long-term motivation for the subject of biology to simultaneously foster scientific competencies. The concept of individual interest is strongly connected with domain knowledge and values associated with that knowledge; yet, the manifestations of an interest are always unique and different for each person (Renninger 2000: 381). For students to develop knowledge and values that result in a well-developed individual interest, teachers have to support students and "their self-perceptions, attributions, goals and task values" (Renninger 2000: 392). Ardasheva & Tretter's (2018) more recent study, however, showed that triggered situational interest is also of great importance to learning and reading comprehension, and it is often the starting point for well-developed individual interest (Ardasheva & Tretter 2018: 639). Hidi (2001) introduced the term topic interest which is a hybrid between individual and situation interest, but has rather fuzzy boundaries to these terms (Ardasheva & Tretter 2018: 634), and, therefore, will not be used in this paper.

There are different models of what text characteristics constitute situational interest. Wade et al (1999), for example, postulate these features: "importance/value, unexpectedness, prior knowledge, ease of comprehension, and writing style" (Wade et al 1999: 197). Chen et al (2001) created several situational models to theorize situational interest. Beside the different weighting of each category, their text characteristics always were "novelty, challenge, attention/demand, exploration/intention, and instant enjoyment". Schraw et al's (2001) division of situational interest includes text-based interests: seductiveness, vividness and coherence; task-based interests: encoding tasks, or changing of the text; and knowledge-based interest. Since the connection between interest and the reading comprehension of a text is under consideration in this section, the focus lies on text-based interests. Seductiveness describes information that, while not being of importance to the understanding of the text, is still very interesting (Schraw & Lehman 2001: 32). Not being of importance can be equated with irrelevant, i.e. it is not related to a step in the cause-and-effect explanation. Studies disagree whether these segments, which increase interest, have negative effects on general comprehension (Schraw & Lehman 2001: 34). Unfortunately, what one identifies as seductive details has not been studied yet, and therefore, one cannot influence the interest of a text through increasing what one personally determines as seductive. However, Harp & Mayer (1997) discovered that adding seductive information negatively influences the learning of scientific explanations for students. Yet there are ways to positively influence learning, namely increasing reading comprehension through making a text more vivid, which has been suggested by several scholars, according to Schraw & Lehman (2001: 35). Vividness describes text that engages the reader through imagery,

concreteness, and creating suspense or surprise (Schraw & Lehman 2001: 34). As remarked when discussing the author's voice, the inclusion of the aforementioned voice increases vividness and consequently interest and comprehension. Schraw & Lehman (2001) discussed studies which modified texts to increase interest of readers, and they concluded that "changes to a text may affect the interestingness of the text and how well it is remembered" (Schraw & Lehman 2001: 39). Harp & Mayer (1997) discussed the connection of interest and learning, and they state that the premise of cognitive interest theory is that the more readers understand a scientific text the more they are interested in it (Harp & Mayer 1997: 93).

While one component of reading, i.e. background knowledge, and its connections to interest have been discussed in the last paragraphs, the other component of reading, which is language knowledge, according to Windhager (2014: 62), has not been addressed in this thesis yet. The language knowledge, i.e. understanding mechanics of language, vocabulary knowledge and syntax (Windhager 2014: 62) has an even closer link to reading comprehension than background knowledge, according to Clapham (1996: 197). Especially vocabulary knowledge has a great influence on reading in a second language. It is mainly the speed of word recognition and the lack in automatic processing skills that hinder fluent reading (Hellekjær 2009: 201). At the same time, top-down processes such as integrating background information and text are important for fluent reading of academic texts in a second language (Hellekjær 2009: 201).

When it comes to different types of reading, Urquhart & Weir (2002: 101-102) mention that the most common types of reading are slow reading, careful reading, and extensive reading. Urquhart & Weir (2002), and Khalifa & Weir (2009) describe careful reading in more detail and subdivide it into a local and a global level. In general, careful reading intends to "extract complete meanings from presented material [through] slow, careful, linear, incremental reading for comprehension" (Khalifa & Weir 2009: 46). Khalifa & Weir (2009) contrast the holistic approach of careful reading with expeditious reading which entails "skimming, search reading and scanning" (Khalifa & Weir 2009: 46). Testing reading comprehension involves expeditious and careful reading to assess the students in "a comprehensive way" (Hinterlehner 2010: 16-17). The literature that influenced the design of the reading comprehension test will be mentioned during the explanation of the empirical study (see chapter 9.2).

After discussing reading in general, one should specify the reading skills needed for science, in- and outside of the classroom. The concept of scientific literacy is the topic of the next chapter.

4. Scientific Literacy

Reading scientific texts can become difficult for students due to the academic features of the genre and the specifically scientific aspects. General academic literacy was described by Zamel (1998: 194) as a “focused exploration of a complex topic”. Academic literacy as a skill needs to be taught to foster the reading of scientific texts (see chapter 5). The same is true for scientific literacy. Norris & Phillips (2003: 226) stress the importance of literacy in science, since it has been overlooked many times. They state that it should be a primary goal of science teaching. They describe literacy as a constitutive of science itself, because there can be no science without reading, talking or writing (Osborne 2006: 206). Yarden et al (2015: 62) mention that there are two meanings of literacy: being able to read and write versus being cultured and educated. According to Norris & Phillips (2003: 233) the first notion describes the fundamental sense of literacy, while the latter is called the derived sense of scientific literacy. They criticize that too much focus is put on ‘literacy as being educated’, through content-focused teaching of scientific ideas, theories and laws. The other aspect of scientific literacy is often neglected, due to some scholars’ simplistic view on reading. As discussed earlier, reading is not only decoding words, rather it is an interactive process between knowledge and text and incorporates skills such as “comprehending, interpreting, analyzing and critiquing texts” (Yarden et al 2015: 63). When reading scientific texts students should, therefore, not only

attend to the substantive scientific content of the texts (the focus of traditional science instruction), but also [see] that they read the texts so as to determine such meanings as degree of certainty being expressed, the scientific status of statements, and the roles of statements in the reasoning that ties together the elements of substantive content (Norris & Phillips 2003: 235).

So, both knowledge of facts and the process of how the information became a fact are important aspects of scientific literacy.

Concerning the development of scientific literacy, Shanahan & Shanahan (2008: 43) describe literacy development in a pyramid model, with basic decoding skills and other bottom-up skills at the base, termed basic literacy. Intermediate literacy is the phase of literacy development in which students are using “more sophisticated responses” (Shanahan & Shanahan 2008: 44) which are not as widely applicable to every single reading situation. The skills acquired in this phase are quicker word recognition, even of multisyllabic words, automated responses to high-frequency words, etc. The top of the literacy development pyramid is achieved only during late high school education, or sometimes never; namely disciplinary literacy (Shanahan & Shanahan

2008: 45). Disciplinary literacy skills are specialized to subject matters, such as history, literature or science (Shanahan & Shanahan 2008: 44).

When it comes to the importance disciplinary literacy, such as scientific literacy, Moje (2008) even goes so far as to demand a new subject exclusively focusing on the teaching of disciplinary literacies. She suggests a metadiscursive approach to foster literacy and critical thinking across the curriculum. While also acknowledging that this would need substantial changes in school structures and institutions' concept of literacy as being more than decoding words (Moje 2008: 105). Concerning the support of critical thinking, reading science always demands interpretation of pragmatic meanings and, consequently, critical reading. Inferential interpretation of pragmatic meaning is a large part of scientific literacy and encompasses inferring meaning through context in order to identify intentions by the author (Norris & Phillips 1994: 948). Yarden et al (2015: 65) state that no education should be doctrinaire, but all subjects should encourage students to be critical of the ideas presented to them; fostering scientific literacy through the use of APL is a way to do that. While there are several ways to introduce new knowledge into the scientific community, such as chapters of books, or conference papers this paper focuses on research articles published in journals. The term journal article is used synonymously. A more detailed description of the research article as a genre is provided in the next section.

5. Primary Scientific Literature – The research article as a genre

There are several approaches to genre, but since this thesis is closely linked with research on English for specific purposes (ESP), the ESP genre approach seems most suitable for this thesis. One of the most important researchers in this field is John Swales, whose definition of genre is that “[a] genre comprises a class of communicative events, the members of which share some set of communicative purposes” (Swales 1990: 58). For a more detailed explanation, he postulates five key features for genre analysis. Firstly, “[g]enre is a class of communicative events” (Swales 1990: 45), which comprise the discourse itself, as well as its participants, the circumstances and historical and cultural associations (Swales 1990: 46). Secondly, “[t]he principal criterial feature that turns a collection of communicative events into a genre is some shared set of communicative purposes” (Swales 1990: 46). Swales' (1990) focus on purpose can be contrasted with approaches that highlight the form of a text as key feature. The third

characteristic of his genre approach is that “[e]xemplars or instances of genres vary in their prototypicality” (Swales 1990: 49). As mentioned earlier, form, structure and audience are not primary characteristics of genres, however, they can be used to determine the prototypicality of a particular genre. Every category has prototypes at the center and other members can still be part of the category but only fulfill a few of the properties of the prototype. Another key feature of a genre is that “[t]he rationale behind a genre establishes constraints on allowable contributions in terms of their content, positioning and form” (Swales 1990: 52). This characteristic presupposes that there is a group of members in the discourse community that realizes the form and content of a genre on a metacognitive level, i.e. the parent discourse community, who then subconsciously allow or do not allow contributions to the genre by apprentice members (Swales 1990: 53). The last key feature is that “[a] discourse community’s nomenclature for genres is an important insight” (Swales 1990: 54). This aspect can be seen in the terms used by routine members of the academic community, who use terms that already give away the purpose, such as ‘introductory lecture’, or ‘research article’ (Swales 1990: 55).

Concerning the genre of the ‘research article’, Swales (1990: 175) uses his theory to distance this genre from the simple notion of research articles being a plain description of investigations, and develop following definition:

[Research articles] are complexly distanced reconstructions of research activities, at least part of this reconstructive process deriving from a need to anticipate and discountenance negative reactions to the knowledge claims being advanced (Swales 1990: 175).

Research papers are seen as very important in academia and proficiency of this genre is closely linked to academic success (Livnat 2012: 21). While some researcher described research articles as expository, the common consent nowadays is that this text genre is highly persuasive (Swales 2004: 218). Even though one could describe the genre of the research article in more detail, the discipline-specific differences are so abundant that Widdowson (1983 in Swales 1990: 175) even suggested to term it a ‘macrogenre’. Hyland (2004) coins the idea of ‘disciplinary cultures’ which emphasizes the differences between disciplines as well as the homogeneity within one discipline (Hyland 2004: 10). This uniformity, however, does not mean that all participants of the same discipline have the same beliefs, quite the opposite is often the case, but members of one field can still engage in common practices, like acknowledging sources and methods, etc. (Hyland 2004: 11). The research article belongs, with other genres such as chapters in books or conference papers, to the umbrella-term used for texts that were

written by the researchers who researched the findings used in their own work: Primary Scientific Literature (PSL) (Yarden et al 2015: 16).

The following paragraphs focus on the language aspects of PSL. Two approaches towards the language of Primary Scientific Literature are discussed separately in this section: the aspect of academic language and the aspect of scientific language. While English in academia is internationally accepted, there are many national differences, for example in reading skills of students. The Programme for International Assessment (PISA) evaluated 15-year-olds reading skills and Austrian students performed better than their American peers (Shanahan & Shanahan 2008: 42). Despite the national differences in some aspects of teaching and reading, scientific literacy is important for science learning all over the world.

CLIL is mostly used in secondary school, but its implications influence tertiary education as well. Gao & Cao (2015: 122) proved that CLIL can even be implemented at a doctoral level at universities to foster motivation for studying English for Academic Purposes (EAP). The use of English for Academic Purposes in secondary education has been studied from many different perspectives. When it comes to the question of why using English instead of the authors' first language, Fløttum (2012: 222) puts it this way: "English is accepted as the lingua franca in large parts of the world today and occupies a privileged position in academia". English is not used in one community of people living on an offshore European island anymore, but "it is an international language" (Widdowson 1998: 241). English as a lingua franca transcends the boundaries imposed on a language by culture and traditions and is used by a wide range of different communities such as the scientific community (Widdowson 1998: 241-242).

The language of EAP differs slightly from field to field, however some characteristics can be found to some extent in all disciplines. De Chazal (2014: 87) summarizes these generalizations into a list of ten characteristics. The first characteristic of academic text is that texts are "written, carefully planned [...], edited [...], and] revised/redrafted" (De Chazal 2014: 87). This aspect of academic language is especially important in teaching the writing of academic texts at university level, but since this paper's focus is on reading it will not be discussed any further. Other items of the list will also not be discussed due to their unambiguous and simple nature, for example that academic texts are "based around sentences" (De Chazal 2014: 87), or that one must not use contractions (De Chazal 2014: 87). As opposed to this, the claim that the "author mostly does not refer to themselves" (De Chazal 2014: 87) is highly dependent on the specific field, the cultural context and the language background (De Chazal 2014: 87). Non-

interactiveness, i.e. not addressing the reader, is also a feature universal to all academic research articles. As part of a larger discourse community, research articles are always addressed to somebody with the aim to persuade this audience (Fløttum 2012: 221). Fløttum (2012: 221) uses the field of evolutionary biology as an example where persuasion is an important feature, but explicit 'addressivity' in form of reader address is not common.

Another aspect of how the text works in its academic discourse is the question of voice in academic and scientific writing, since "the rhetoric of downplaying the interpersonal while foregrounding complex contents, [is a] characteristic of academic discourse" (Silver 2012: 202). In general, voice does not only describe 'who is speaking', rather it is the authors' discursive identity which has to anticipate the readers' views and incorporate those projected reader positions into his/her writing (Silver 2012: 202). Voice as a socially influenced question of identity leads to differences between disciplines and cultures. A basic distinction concerning the term voice has been described by Sinclair (1988). He coined the terms "'averral', the unmarked or default condition of written texts, where the reader is led to assume that the voice making affirmations is the writer's own, and 'attribution', where a proposition is explicitly indicated as deriving from a source" (Silver 2012: 204). The author can convey his position to the scientific community through these two techniques. Silver (2012) identified one intention these techniques were used for in nearly all research papers of the field of microbiology they studied; both averral and attribution were used to highlight the importance of the research for the specific field and beyond. Additionally, the research showed that microbiologists minimize subjectivity and personality strongly and subordinate the writer's voice to the scientific method (Silver 2012: 215). These aspects, however, can also be related to cultural differences. Sanderson (2008) studied variations in academic language between British, US-American and German scholars, and her research shows that the "British and US-American scholars were more likely than German scholars to refer to themselves and address the imagined reader" (Sanderson 2008: 275). Other studies support this difference between non-native and native users of English and their use of first person personal pronouns. Concerning research articles in the field of biology, Martinez (2005) shows that native English scholars use twice as many first-person pronouns than their non-native colleagues. The attempt to reduce author visibility through not using first person pronouns is a strategy to increase the validity of the claims (Lorés-Sanz 2001: 174). In contrast to the benefit of avoiding 'we/I' stands the need to construct a confident voice which reflects authority in the competitive world of science (Lorés-Sanz 2001: 174). Lorés-Sanz (2001) studies the tension between the cultural influence of Spanish scholars which suggests not to use first person pronouns, and the linguistic background on English that

prefers the use of 'we/I' to establish oneself as an academic persona in the world of science. She concludes that the disciplinary context plays a more important role than transfers of one's own culture (Lorés-Sanz 2001: 190). Her findings also show that scholars coming from an Anglo-American context use the most first person pronouns, followed by native Spanish scholars writing in English and the fewest amount was found in Spanish scholars' Spanish research articles (Lorés-Sanz 2001: 179), therefore, the linguistic background of the research article seems to have an impact on their decision to use 'we/I' and consequently on their construction of an academic voice. Elbow (1998: 18) also mentions the differences between British and the German scholarly tradition. British scholars tend to use citations and references only to a minimum, whereas German authors try to support all their claims with as much evidence as possible. Another difference is that German scholars use more explanatory linking devices than their British colleagues (Elbow 1998: 18).

Another feature of academic language, according to De Chazal (2014: 87), is the pattern of presenting given information first and continue with new information. This can be seen at a sentence level as well as on a structural level with background information at first and the results of the new study later on. Concerning the grammatical aspect of academic texts, there are some features that De Chazal (2014: 87) summarizes as "clauses [...] adapted to fit the requirements of communication". He mentions the use of the existential 'there', clefting, and the passive form as examples. These features are used to decrease subjectivity and shift the focus away from the author. Another characteristic is the use of linking devices to increase coherence and foster understanding, such as 'in contrast', etc. (De Chazal 2014: 87). Another general characteristic mentioned by De Chazal (2014: 87) is that academic language is "[g]rammatically complete; low instance of error; long sentences, complex structures, especially noun phrases". Grammatical completeness and rare errors are qualities of many text genres, but the complexity of noun phrases and the long sentences are widely accepted as main characteristics of academic language. These two features are crucial for syntactic simplification and will be discussed in detail in chapter 7.6.

When it comes to the topic of lexis in academic texts, Hellekjær (2009: 211) discovered that unfamiliar vocabulary is one of the biggest problems in reading comprehension of academic texts. One important feature, especially in context of APL, is morphological complexity of academic vocabulary (De Chazal 2014: 87). This aspect of EAP should be taken into account when adapting PSL. Through academic word lists one can identify academic vocabulary and replace it with less morphologically complex words, as described in chapter 7.5 on lexical

modification. Hyland & Tse (2007: 236) describe the issue of vocabulary from a different perspective, namely word lists. A high-frequency word list usually covers 80% of an academic text, 8-10% academic vocabulary and 5% technical vocabulary. Focusing on these 8-10% of academic vocabulary, Nation & Coxhead (2013: 1) describe two reasons for its existence. First, some academic words convey formality through their origins in Latin, and secondly, academic vocabulary is needed for expressing the purposes of academic texts. According to Nation & Coxhead (2013: 1), these are “to review previous research, to evaluate that research, to describe the methodology of a piece of research, to describe the results of the research, and to suggest the implications and applications of the results”. General academic lexis differs from the discipline-specific one in that general academic words also have a meaning in everyday language which differs from the meaning in an academic context (Adebisin 2015: 27). The challenge of acquiring a new concept for an already known word was described by Posner et al (1982) with his conceptual change model (CCM). This model states that a concept which is not satisfactory anymore can be replaced with an intelligible and plausible new concept. In science learning, this new concept is introduced with new specialized vocabulary and finally accommodation occurs (Adebisin 2015: 27). In a study in an international school in Vienna, Adebisin (2015) discovered that all participating students identified the reason for being bad in science is due to their lack of academic vocabulary knowledge. The discussion of ‘academic English’ draws largely from the field of English for Academic Purposes (EAP). The broader approach EAP belongs to is called English for Specific Purposes (De Chazal 2014: 5). Other sub-categories include ‘scientific English’, which will be dealt with in the next paragraphs. Since science practices are performed to a great extent at academic institutions, the language used by scientists includes specific features not common to other fields. Therefore, scientific English is discussed separately as a specialized sub-category of academic English.

According to Gordin (2015: 3), the definition of ‘science’ is narrower in the English language than in other languages and is sometimes also used as a synonym with natural sciences. Consequently, the discourse community of primary scientific articles are a “comparatively small community of elite, professional scientists, a community that has engaged in international communication for centuries and maintains to the present the highest prestige among investigators of nature” (Gordin 2015: 3). One can differentiate between two concepts, when it comes to communicating science. On the one hand ‘science communication’ which describes scientists presenting their work to non- members of the community and ‘scientific communication’ in which science share their knowledge within the community (Rakedzon et

al 2017: 2). Another characteristic of the scientific communication is that its discourse is cumulative in that every research article adds to the discipline and alters the overall science discourse (Osborne 2002: 211).

General stylistic devices of scientific research articles are the conventional format (Introduction, Methods, Results, Discussion), omission of unsuccessful steps, and the exclusion of references towards the researcher's opinion (Hyland 1998: 15). The data neglected includes random anomalies, errors through contaminated conditions, and "distortions by scientists who hold unscientific biases or wrong theories" (Beaugrande 1997: 132). Research articles complete and specify the existing knowledge through "adding on facts [...] and making them more exact" (Beaugrande 1997: 132). While all these features aim at presenting new knowledge as objective, scientific research is very much determined by the social and cultural circumstances (Hyland 1998: 15). Ken Hyland, one of the most influential scholars on this topic states that scientific language serves two functions. On the one hand the language supports scientists' competing interests, and on the other hand it maintains the authority of science itself (Hyland 1998: 16). This method for emphasizing science's authority also has an alienating effect and excludes non-members of the discourse community, for example high-school students. One aspect of scientific language is that it contains not only words, but diagrams, pictures, and graphs, etc (Osborne 2002: 210).

Concerning the use of English in science, Ammon (2012) studied the historical changes from 1880 to 2005 and he discovered that the percentage of English among the globally published science papers increased from 38 % in 1880 to more than 90% in 2005. All other languages, like Russian, Japanese and German decreased in that period. In the German academic community projects like the 'PEPG (Publish in English or Perish in German?)' studied non-native scholars' problems resulting from writing scientific texts in a different language (Gnutzmann et al 2015: 66). Over a third of the problems Gnutzmann et al's (2015: 66-67) participants described, originated from linguistic difficulty ("phrasing English", or grammatical and lexical problems). This study also tried to identify resources of German speaking scholars who published in English and 16 out of 36 interviewees stated that the reading of articles published in English helped their language competence and their own writing (Gnutzmann et al 2015: 70). Nevertheless, Busch-Lauer (2000) states that in the German scientific discourse, the language of PSL articles is even more complex than the one used by other non-native scholars, due to the use of conventions of the L1 (Busch-Lauer 2000: 93). The import of highly

complex structures from the L1 could also have a negative impact on the writing of scientific texts.

One aspect of general academic and scientific English is ‘hedging’ which refers to “any linguistic means used to indicate either a) a lack of complete commitment to the truth value of an accompanying proposition, or b) a desire not to express that commitment categorically” (Hyland 1998: 1). This essential element of scientific writing is crucial for the presentation of new, unproven postulations in a cautious way so other scholars can discuss and ratify them (Hyland 1998: 6). Understanding ‘hedging’ helps the reader and adapter to identify the author’s argument and, consequently, improve the product of adaptation. Hyland (1998: 214) identifies three categories of hedges: reader-oriented, writer-oriented and accuracy-oriented hedges. When writing a scientific research article, the author has to keep the ratification of his/her hypothesis by the audience in mind, and in some disciplines, this is done through acknowledging different claims and emphasizing personal involvement, i.e. reader-oriented hedges (Hyland 1998: 177-184). As Hyland’s (1998: 214) study discovered this is not very prominent in scientific research articles. In contrast to that, writer-oriented hedges are important for scientific writing. These hedges reduce the author’s presence and are used when describing new contributions to protect the writer from possible critique (Hyland 1998: 170). One of Hyland’s (1998: 170) interview partners explains the reason in this way:

Scientists are fallible and so are their methods. Most of the time you could be right but there is often a chance that it might be something different and you'd better make sure you let people know that before they let you know.

Lastly, accuracy-oriented hedges are increasing precision through detailed descriptions of how the claims have to be understood (Hyland 1998: 170). The amount of these three types of hedges varies between disciplines, but also within in article between the different sections.

Osborne (2002) describes some of the complexities of scientific language, for example polysemy (Osborne 2002: 209). That nearly all words are polysemous, has been exposed by several researchers, according to Osborne (2002: 209). This polysemy is especially important in scientific language, since scientists “want their words to be purely technical signs with no index of meanings” (Osborne 2002: 209), yet, “precise meanings in a subject like science, may be a difficult notion” (Cervetti et al 2015: 176). The importance of context for meaning will also be a topic in a later chapter, when discussing synonymy for lexical modification.

When reading up on scientific vocabulary research, one cannot omit the term ‘jargon’. Jargon is defined in the Oxford English Dictionary as “any mode of speech abounding in unfamiliar terms, or peculiar to a particular set of persons, as the language of scholars or philosophers, the terminology of a science or art” (OED “jargon” 6.). Concerning the teaching of biology, the extensive amount of jargon may have a negative influence on science learning (McDonnell et al 2016: 12). McDonnell et al (2016) replaced jargon with everyday language when introducing a new concept, such as DNA. Their findings suggest that this jargon substitution supported students’ understanding of science (McDonnell et al 2016: 17) For scientists themselves, however, communicating science can be difficult due to the ‘curse of knowledge’ through which scientists cannot remember that at an earlier stage in life they did not have the knowledge to understand their highly specialized text either, and therefore, they find it hard to identify the jargon in their writing (Rakedzon et al 2017: 2). When it comes to the number of new words in school science texts, Osborne (2002: 210) mentions that students are confronted with more new vocabulary in science teaching than in language teaching, due to the high number of technical terms in school science texts.

In general, science authors strive to describe phenomena in a precise and concise manner (Gladon et al 2011: 116). Through the complexity of the subject, however, complex syntax is sometimes needed to convey the intended meaning. When it comes to syntax of scientific English, Cheong (1978) identified nine major grammatical areas. These areas have been compiled in table 3.

Table 3: Major grammatical areas of scientific English (Cheong 1978: 23-209)

Mood
Voice
Basic Structures
Modal Constructions
Complementation
Relativization
Comparison
Adjunction: The use of connectives
Co-ordination

Cheong (1978) starts with explaining the four mood categories for independent clauses, i.e. declarative, imperative, interrogative, and exclamative. Cheong’s (1978: 27) study found out

that more than 90% of sentences in his corpus of scientific English were declarative. A common declarative structure started with the empty-subject *It* as in “It is assumed ...” (Cheong 1978: 29) (see ‘hedging’ above). He continues with discussing the use of modal constructions in scientific texts. While *must* and *should* are used to convey confidence in the hypothesis, *could*, *might* and *would* show more speculation and less confidence. The modal verb most often used was *can* (Cheong 1978: 68), which also conveys a degree of uncertainty. Another grammatical feature typical for scientific English is sentential complementation. Cheong describes complements as “the obligatory element[s] that follow the main verb” (Cheong 1978: 86), which can take on numerous forms. Relativizations of noun phrases through relative clauses are another important aspect of scientific English (Cheong 1978: 110). The same is true for comparative constructions which are often references pointing forward (cataphora), pointing backwards (anaphora), or implicit references (homophora) (Cheong 1978: 142-143). Waring (2013: 10) even suggests that the grammatical feature of references is hindering the comprehension of scientific texts. Another characteristic of scientific English are adjunctions used to connect clauses and show the relationship between scientific facts (Cheong 1978: 162). Clauses of exposition and argument are connected through such adjunctions, which can also emphasize the logicity of the conclusions. The relationships highlighted through adjunctions are very diverse, as are the adjuncts. For example, to stress the logical sequence/ cause effect relationship, the following adjuncts have been identified: “so, therefore, hence, thus, as a result, accordingly, consequently” (Cheong 1978: 166). The last grammatical features mentioned by Cheong (1978) are coordination devices. Through connecting two sentences without elevating one’s status over the other sentence’s status, compound sentences are created. A high amount of compound sentences and complex sentences are characteristics of scientific English and also add to the difficulty of scientific texts (Keshavarz et al 2007: 24). These nine aspects of the syntax of scientific English are of great importance for scientific literacy and science teaching.

When it comes to visuals in science, Ardasheva et al (2018: 632) consider them “to be an effective instructional tool in helping students [...] comprehend better what is being read”. In PSL as well as APL visuals can add “concreteness, [and] representational visuals are most beneficial for ELs [note: English learners] by providing additional (visual) associations and redundancy (image plus text) of input” (Ardasheva et al 2018: 633). Norris et al (2012: 128-130) summarize five features of visualizations relevant to science education. According to them, visualizations should be relevant in that they refer to existing knowledge, as well as contribute to the educational goal. An overly detailed graph, rich in elements, is hard to interpret

for students. In addition to the aspect of ‘relevance’ of visualizations, Norris et al (2012: 129) mention ‘appeal’ as another feature of visuals, which is, however, less important in the context of science education. Realism, however, is important for science, as it “represents how true to the physical world the visualization object is” (Norris et al 2012: 129). Summarized as one feature are all visual properties, such as color, texture, spatial properties etc. which are also important for interpreting visuals and promoting interest. The last feature of visualizations in science education does not really apply to PSL or APL, since it is called ‘Animation and Interactivity’. The addition of the dimension of time can help students understand concepts from evolution to cell reproduction.

All these features of PSL mentioned in this section have to be considered for the adaptation process from a PSL text to an APL text. Some should be reduced, others highlighted, and some additions should be made as well. A description of the genre of Adapted Primary Literature is the topic of the next chapter.

6. Approaches to adapting PSL for pedagogical purposes

This diploma thesis tries to combine two approaches of text adaptation and apply them to an example PSL text. Firstly, there is the approach originating from the field of science education and developed by several scholars including Anat Yarden, Stephen P. Norris and Linda M. Phillips (e.g. Yarden & Brill 2000, Yarden, Brill & Falk 2001, Norris & Phillips 2003, Yarden & Brill 2003, Yarden, Brill & Falk 2008, Yarden 2009, Yarden & Falk 2009, Phillips & Norris 2009, Norris et al 2009, Norris, Stelnicki & de Vries 2011, Yarden & Falk 2011, Norris 2012, Yarden, Norris & Phillips 2015). Secondly, there is the linguistics approach of input modification with different studies focusing on different effects of language simplification and elaboration (Yano et al 1994, Ragan 2006, Oh 2001, Rahimi 2011, Kasgari 2018, etc.). The former will be the subject of the next section.

6.1. The science education approach: APL

The term ‘Primary Scientific Literature’ was used by Yarden et al (2015), which serves as an important source for this thesis. ‘Primary’ refers to the fact that the authors of these articles conduct the experiments and collect the data themselves. The audience for this genre belongs to the same group as the authors, i.e. scientists (Yarden et al 2015: 17). The communicative purpose of scientists writing these texts is to present the newly collected evidence which is then used as an argument to support or contradict existing theories or facts (Yarden et al 2015: 25).

While the argumentative aspect is the main purpose; exposition of information is also present, in some sections more than in others (Yarden et al 2015: 18). Zamel (1998: 194) proposes “that we involve students in authentic work by immersing them in reading, writing, and language, by engaging them in rich course material, by providing them with multiple and extensive opportunities to inquire into, raise questions about, critically examine this material, by inviting them to see connections between their own perspectives and course content”.

Primary Scientific Literature and Adapted Primary Literature naturally have many similarities since one is derived from the other. The historical development of the research of Adapted Primary Literature will be discussed in the next few paragraphs.

The term ‘Adapted Primary Literature’ consists of three parts: Literature can be defined through many different approaches. In this thesis the simple, but not uncontended, notion of literature as being “[t]he result or product of literary activity; written works considered collectively” (OED “literature” 3a.) will be used. ‘Primary’ refers to the fact that the authors of these articles generate and collect their own data. The writers then use the gathered data to draw (broader) conclusions (Bazerman 1988, Goldman and Bisanz 2002). In 2001, nearly 40 years later after the first appearance of the idea of adapting scientific articles for educational purposes, Yarden, Falk & Brill (2008) take up this concept and develop a biology curriculum based on processed research articles. While this paper already describes the concept of ‘Adapted Primary Literature’, the term itself was first used by Baram-Tsabari & Yarden in 2003. The goal of APL is described as “to overcome the gap between the highly professional nature of research articles and the cognitive level of high-school students” (Yarden et al 2001: 191). The adaptations “only meant to simplify the text, but not to change it significantly [, therefore, they] retained the common structure of a research article as well as the authentic results and illustrations” (Baram-Tsabari & Yarden 2004: 404).

After clarifying the basic definition of Adapted Primary Literature, a short historical overview of the research on APL is necessary. The brevity of this overview is not due to the restrictions of this thesis, rather because of the juvenescence and size of this field of research itself. The term ‘Adapted Primary Literature’ has been coined by Yarden, Falk & Brill (2008), although, the first scholar that mentioned the idea of excerpting, translating and editing scientific articles was Joseph Schwab in 1962 (Schwab 1962). This small appearance of the concept of adapting scientific articles was followed by nearly 40 years of stagnation concerning this idea. In the year 2000, Anat Yarden and Gilat Brill wrote their first paper on the use of primary literature for a course on embryonic development, which was, however, only published in Hebrew and

Arabic. One year later, Yarden, Brill & Falk (2001) expanded the notion of using primary literature by using it as basis for a full high-school biology curriculum. While they describe main adaptation processes, the term ‘adaptation’ is not introduced yet. The next publication by Yarden & Brill (2003) studied a more specific connection of high-school science teaching and research papers, namely the use of primary literature to stimulate question-asking from students. After this quantitative study, which showed beneficial effects of using research papers in science teaching, Yarden, Brill & Falk (2004) continued their research in this field with a qualitative study based on the reading of the same texts which were processed for the previous study (Yarden & Brill 2003). The qualitative study resulted in a list of reading strategies and the suggestion to include questions created by students into the teaching to foster a deep understanding.

All of the previously mentioned studies were undertaken at the Weizmann Institute of Science in Rehovot, Israel, and the same is true for the next one, which was again written by Anat Yarden, the leading expert in APL for biology teaching. Baram-Tsabari & Yarden (2004) contrasted two genres and their effects on students’ formation of scientific literacy. Although the term ‘Adapted Primary Literature’ is mentioned, it is not described as a genre of its own but as belonging to the genre of scientific research article (Baram-Tsabari & Yarden 2004: 403). This text type of APL is contrasted with the popular scientific genre, i.e. secondary literature, and their results show that, while secondary literature helps student fill gaps in their prior knowledge, Adapted Primary Literature enhances their understanding of scientific inquiry.

The next important step of research on Adapted Primary Literature was the first description of this text type as a distinct genre in Yarden, Falk & Brill’s (2008) paper in which they applied their experience in creating a curriculum for developmental biology to a new biotechnology curriculum. The main difference here is not the different teaching subject, but that in contrast to their earlier work, they explicitly describe Adapted Primary Literature with its aims and characteristics.

In a later work Yarden et al (2015) state that the late introduction of the term happened due to a long discussion on the question if APL is a distinct genre or belongs to Primary Scientific Literature, a term discussed in more detail later. The main arguments for APL to be named its own genre were “(i) in contrast to primary literature, the writers of the articles are not (necessarily) or not only the scientists who carried out the research; and (ii) the target audience is high school students rather than scientists” (Yarden et al 2015: 8). The benefits of APL that Yarden, Falk & Brill found in 2008 were mostly concerning scientific skills rather than

language development, for example “[u]nderstanding the nature of science” (Yarden, Falk & Brill 2008: 1854) and “inquiry thinking” (Yarden, Falk & Brill 2008: 1852).

Originally, the Israeli Ministry prescribed the use of APL for 16-18 year-olds (Yarden, Falk & Brill 2008: 1843), yet, only one year later, Ford (2009) wrote a commentary on “Promises and Challenges for the Use of Adapted Primary Literature in Science Curricula” which supports the application of APL at a tertiary level as well. Her claims include that one can even implement easy Adapted Primary Literature in education for younger students of secondary or even primary education. Ford (2009: 389) also stresses that teachers need to be proficient in teaching science and in teaching literacy. The commentary was published two weeks before eight new papers were published online and later in print in the May issue of *Research in Science Education*.

The increasing amount of publications shows the growing attention this novel genre got after its appearance in the Israeli biology curriculum. The journal issue mentioned above had the subtitle “Adapting Primary Literature for Promoting Scientific Literacy” and included a rejoinder to Ford’s (2009) commentary. The author-team of this rejoinder consisted mainly of scholars who were cited in Ford’s (2009) original commentary, namely Yarden, Falk, Norris, Phillips, and Jimenez-Aleixandre & Federico-Agraso. As Ford did not criticize their work, but gave supporting arguments for a wider implementation, their article (Yarden et al 2009a) also did not condemn her remarks but tried to explain some aspects, like the question of authenticity, in more detail. Additionally, Yarden et al (2009a) present their already developed curricula and texts that can be used to support teachers of APL.

In the editorial of this issue, Yarden (2009) defines Adapted Primary Literature through contrasting it with different scientific text genres used for science learning for the first time. After the editorial, volume 39 issue 4 of *Research in Science Education* starts with Philips & Norris (2009) who contrast language of school science with language of science and the opportunity APL offers to bridge those two. This theoretical research focuses for the first time on the language aspect of Adapted Primary Literature, and not on inquiry skills or other scientific skills. Another addition to the field is offered by Norris et al (2009), who present another example of APL, only this time for mathematical biology, and have simulated the Israeli research in a Canadian setting and included the topic of motivation and interest.

Besides Primary Scientific Literature and Adapted Primary Literature, the scientific genre of Journalistic Reported Versions is also used for science education and is present in this issue.

Jimenez-Aleixandre & Federico-Agraso (2009) discuss the translation of the argumentative structure from the PSL into the JRV, by exemplifying it on a paper with the topic of cloning. The genre of Journalistic Reported Version, which includes for example newspaper articles, will be examined in a later chapter (see chapter 6.1). Another paper in this issue, namely Yarden & Falk (2009) observed the implementation of their previously developed biotechnology curriculum (Yarden, Falk & Brill 2008) with focus on students' coordination practices, i.e. how the students used the APL to connect elements from different epistemic levels (Yarden & Falk 2009: 353).

The whole issue 39 of the journal *Research in Science Education* has been reviewed by Jonathan Osborne, whose review was also published in the issue, together with a rejoinder from the main authors (Norris, Falk, Federico-Agraso, Jiménez-Aleixandre, Phillips & Yarden 2009). In contrast to Ford (2009), Osborne (2009) criticizes some of the assumptions underlying the other papers' theses. Firstly, he disapproves of the notion that APL helps students understand the nature of science, and the way it is commonly presented (Osborne 2009: 399). He claims that since most of the representation of science that students encounter will be through the media and not journals (Osborne 2009: 399). Therefore, it is better to use Journalistic Reported Versions. Yarden et al (2009) reply in their rejoinder that both genres have their benefits and reading APL fosters students' critical reading of media reports, i.e. JRV. The second assumption Osborne (2009: 400) criticizes is that reading is an act of inquiry. While he claims that reading consists of several processes which require inquiry skills, reading itself is not inquiry. The rejoinder (Yarden et al 2009b: 407) sticks to the opinion that, in science, reading is part of scientific inquiry, same as calculating, observing, measuring etc. and therefore, can be seen as inquiry as well. Another, maybe less pedantic, critique by Osborne (2009: 400) is that authenticity is not a sufficient justification for anything in educational science, because authenticity is not a guarantee for effectiveness. Yarden et al (2009b: 407) acknowledge the differences between school science and academic science, yet they see the primary educational value of using APL to learn "how scientific theories are justified" (Yarden et al 2009b: 407). Overall, issue 4 of volume 39 of *Research in Science Education* presents a collection of papers that created many opportunities for further research and can be seen as the starting point for an international support of Adapted Primary Literature.

The next important addition to the field was the introduction of 'Hybrid Adapted Primary Literature' by Shanahan et al (2009). HAPL differs from APL in that the adaptor also adds a narrative text introducing the scientist and their research (Shanahan 2009 et al: 22) before the

usual APL text. In contrast to the parts of scientific language maintained in APL, narrative writing is action-oriented, i.e. not written in a passive voice; concrete, i.e. only few abstract noun phrases; and “directly notes the people involved including their thoughts, motivations and actions” (Shanahan et al 2009: 22). The benefit of including this introductory narrative is that students get the opportunity to learn about the personal motivation and importance of the article for the field as well as how the evidence collected has been used in the scientific community (Shanahan 2012: 61). The content of the narrative introduction is gathered through supporting materials, such as interviews or press releases (Shanahan et al 2009: 23). Shanahan et al (2009) also carried out a pilot study to test HAPL’s effectiveness in supporting understanding of scientific inquiry and identify room for improvement (Shanahan 2009 et al: 24). Through student observations and questions, they discovered that HAPL helps students understand the following:

the connections between evidence and explanation in science, the personal motivation of scientists, the tremendous effort and time required for scientific research, and the place of research reports, not as repositories of absolute knowledge, but as reports of scientists making sense of available evidence to the best of their abilities (Shanahan 2009: 24).

The idea of HAPL was further developed in Shanahan’s (2012) chapter in Norris’s book on *Reading for Evidence and Interpreting Visualizations in Mathematics and Science Education*. Shanahan does not focus on visualization, but rather on epistemological and meta-language aspects of Primary Scientific Literature. While “[e]pistemological language is used by scientists to construct and describe their meaning and reasoning” (Shanahan 2012: 43), metalanguage is “used to analyse and describe the generation of scientific knowledge” (Shanahan 2012: 44). To present these two aspects of scientific language to elementary students, she used the concept of ‘Hybrid Adapted Primary Literature’.

Following Yarden’s, Falk’s, Brill’s, and other scholars’ large contributions to the field of APL in 2009, the applications of the theory had to be observed next. Yarden & Falk (2011) received some reluctant feedback from teachers who were afraid that students would not be able to comprehend Adapted Primary Literature (Yarden & Falk 2011: 78), and consequently, examined three instructional approaches observed in Israeli schools. The teachers observed all used the opening sections of the previously adapted biotechnology article (Yarden, Falk & Brill 2008). However, their teaching approached differed very much. Past research by Yarden et al (2001) suggested a conversational model of teaching APL, in which the students only read the article part by part and the teacher scaffolds the students’ understanding through comments, questions and additionally prompts students to ask questions themselves (Yarden & Falk 2011:

79). This model is often criticized due to its time-consuming iterative stages (Yarden & Falk 2011: 81). A newly introduced approach is the “[p]roblem-solving model” (Yarden & Falk 2011: 79). which is based on Schwab’s (1962) ‘invitation to inquiry’ proposal. When using this approach, the teacher presents a problem similar to the one answered by the research article to the students, and then they try to find a solution and a consensus. After they have reached a viable solution, the article is read, to show them how the author has dealt with the problem. (Yarden & Falk 2011: 80). While this approach has a strong focus on scientific inquiry learning, it reduces the opportunity for students to use an article as source for information and the teacher has to be the main information provider when using this model (Yarden & Falk 2011: 81). The third and last suggested model is the ‘scientific literacy model’. This approach makes use of the different genres of scientific texts for educational purposes. By presenting a JRV text on the same topic as the APL text, one can highlight each of the significant and beneficial features of each genre. The teacher of Yarden & Falk’s (2011) study presented the journalistic reported version first which helped students be more confident in reading the Adapted Primary Literature, since they already knew information presented in the opening paragraph (Yarden & Falk 2011: 81). After re-reading the JRV, they were able to identify misleading sentences, which were not in line with the APL article. This approach presumes that both types of texts are available, yet if one does not create an adapted version oneself, finding an APL version and media report is very hard, if not impossible. Conclusively, Yarden & Falk (2011: 82) suggest varying these three models in science teaching, since each one has its benefits and limitations.

Other researchers of the Weizmann Institute of Science in Israel joined the group around Anat Yarden and published a paper on APL in the field of physics education (Langbeheim et al 2013). They examined the important aspect of keeping the PSL article’s purpose and meaning the same despite the adaptations. Their findings suggest that the purpose of the papers they adapted was successfully transmitted into the APL version and students were able to identify said purpose. While their designing guidelines were rather simple and will be discussed later, the next publication described the adaptation processes in a little more detail.

The latest publication is the most important one in the field of Adapted Primary Literature, since it consists of 248 pages describing nearly every aspect of the field. Through gathering all the information that has been already mentioned in this chapter and much more, Yarden, Norris & Philips created an overview which covers the origins of APL, a thorough theoretical discussion, and practical examples with additional comments. The book’s title is *Adapted Primary Literature: The Use of Authentic Scientific Texts in Secondary Schools* and it was dedicated to

one of the authors, Stephen P. Norris who was already deceased at the time of publication (Yarden et al 2015: xiii). Since it comprises most of the research executed up until 2015 and is also the most recent publication on APL, this publication is used for reference in several of the following chapters as well.

To define the genre of APL more clearly, one can contrast it with other genres of scientific texts. While Primary Scientific Literature has already been discussed as tool for scientific communication (between scientists), there is another genre that has been mentioned but not explained in detail, namely Journalistic Reported Versions of scientific texts. Yarden et al (2015) describe JRV as resembling textbook texts more than authentic Primary Scientific Literature, even more so than APL. This resemblance is due to the lack of the canonical structure and supporting evidence and JRV also “presents scientific knowledge as certain” (Yarden et al 2015: 18). When it comes to the comparison of the three genres PSL, APL, and JRV, Yarden et al (2015: 17) present six dimensions in which these three genres of scientific text differ. Firstly, the authors of PSL are usually scientist, whereas APL has a combined authorship of the original scientist author and the science educator who adapted the text. As the name suggests, Journalistic Reported Versions are written by science journalists. The second difference is the target audience. As mentioned in chapter 5, the target audience of PSL is the scientific discourse community, which consists of other scientists. APL is directed at students of high school science, and JRV at the general public. Thirdly, Yarden et al (2015: 17) describe that the main text type of both PSL and APL is argumentative, in contrast to the sometimes expository, and sometimes narrative structure of JRV. When it comes to the content, PSL and APL again share the same characteristic, namely “evidence and reasons to support conclusions” (Yarden et al 2015: 17). JRV does not include that much evidence and supporting reasons, and rather portrays the newly acquired knowledge as facts, which leads us to the next dimension of how science is presented. PSL and APL authors portray at least a small amount of uncertainty through hedging and other techniques so that they do not lose face if someone modifies or falsifies their work (Lorés-Sanz 2001: 179). In contrast to that, JRVs, such as media reports, depict the findings of a new study with more certainty, but still not as absolute knowledge (Yarden et al 2015: 17). The last dimension for characterizing the three genres of scientific text is the organizational structure. This is the most important dimension for APL, since keeping the canonical structure and teaching students the structure of an article, but with easier language and content, is an important reason for including APL in the curriculum. JRV on the other hand does not follow this canonical IMRD pattern. The topic of structure will be discussed in more detail in chapter 7.4 on structural standardization.

6.2. The linguistic approach: Theory of input modification

This chapter discusses different approaches to input modification. As mentioned in the introduction, one aim of this thesis is to incorporate general theory on text modification, often used for graded readers and other text genres, into the field of Adapted Primary Literature, which has not been done in detail yet, neither by Yarden nor other scholars. ‘Input’ is defined by Oh (2001: 69) as “all types of linguistic data from a target language that learners are exposed to and from which they learn”. In an earlier study the two different types of input modification are described as: “simplification, in the form of less complex vocabulary and syntax, and elaboration, in which unfamiliar linguistic items are offset with redundancy and explicitness” (Yano et al 1994 in Oh 2001: 69). A more detailed distinction will be presented in the next paragraphs.

The term ‘simplification’ with reference to texts originated in research on graded readers. The genre of graded readers consists of “books which are specially written or adapted for second language learners” (Nation & Wang Ming-tzu 1999: 356). The difference to the large amount of existing research and this thesis is that the source genre for graded readers are mainly narrative texts, which are action-oriented (Shanahan et al 2009: 22), whereas Adapted Primary Literature (APL) uses Primary Scientific Literature (PSL) as basis for the adaptation. Nevertheless, the processes involved are very similar.

Linguistic simplification in the context of language teaching is defined by Widdowson (1980: 185) as “a kind of intralingual translation whereby a piece of discourse is reduced to a version written in the supposed interlanguage of the learner”. There has been a debate on text simplification for quite some time, and while some scholars have shown that simplification does not necessarily lead to better reading comprehension (Blau 1982, Yano et al 1994, Parker & Chaudron 1987), the opposite has been the result of other research, e.g. Kameenui et al (1982) and Mitchell et al (1984). A study developed by Tweissi (1998: 200) showed that text simplification for better reading comprehension in English as second language learners works in general, however, too much simplification, especially of syntax, may lead to unnatural language and, therefore, decrease comprehension (Tweissi 1998: 200). While the studies mentioned in this paragraph show the beginnings of simplification theory, more recent research exists as well.

A more recent approach to text simplification arose out of research on natural language processing with the use of machine translation (e.g. Biemann & Yimam 2018, Sevens et al

2018, Xu et al 2015, Perera & Kosseim 2013, Lin & Wilbur 2007, Jonnalagadda & Gonzalez 2010). Most of the language processing programs, presented and reviewed in this field aim for improving information instruction and discourse analysis, and not “human readability” (Jonnalagadda & Gonzalez 2010: 351). Yet, there is one study that attempts to improve comprehension through a natural language processing program, namely Kandula et al (2010). While the computer program is not directly applicable to the simplification of the text genre of Primary Scientific Literature, it is used later on, to present a simplistic approach of syntactical simplification. Other research on natural language processing programs will not be subject of the following chapter, since this diploma thesis focuses on CLIL in Austria, and Austrian teachers often do not have the time and resources for using complex simplification programs and machine learning. Additionally, the language of PSL differs from the genre-specific language these programs were created for, and therefore they will not be discussed any further.

When discussing the issue of linguistic simplification, one has to examine the different aspects of the term as well. To present a chronological overview of the debate on the two main aspects of simplification one has to look back to the beginnings of simplification theory. An early paper by Chaudron (1983: 439) distinguishes between restrictive simplification (linguistic adjustment) and elaborative simplification. These concepts have been further developed into two categories of simplification often seen as opposites: simplification versus elaboration (Oh 2001, Rahimi 2011). When first presenting this distinction Chaudron (1983) distinguished these two ways of simplifying a text through word count alteration. A modification increasing the word number was termed elaborative simplification and when it reduced the word count, he called it restrictive simplification. This thesis uses the modern terms of *simplification* and *elaboration* as distinct strategies, while the term *modification* is used as an umbrella term for both strategies.

More recent studies made further distinctions and assigned several methods to simplification and elaboration. Oh (2001) lists features of simplification in his article *Two Types of Input Modification and EFL Reading Comprehension: Simplification Versus Elaboration*:

the use of shorter sentences (in words or in T-units), simpler syntax (in clauses or S-nodes per T-unit), simpler lexis (smaller type-token ratios and avoidance of low frequency vocabulary), deletion of sentence elements or morphological inflection, and preference for canonical word order (Oh 2001: 70).

The different components of this list of simplification strategies will be discussed later in distinct chapters. Some terms used in the quote above are in need of clarification. Introduced by Hunt (1965) a T-unit consists of a main clause and every subordinate clause or even non-

clausal structures that are attached to the main clause or embedded in it (Hunt 1965: 20-21). Another term in need of an explanation is ‘S-node’. ‘Sentence-nodes’ are indicated by tensed and untensed verbs. To exemplify the calculation of syntactical complexity, one can compare two t-units: “Cross-pollination is possible in areas with hybridisation partners such as Mexico” (Pascher 2016: 2) (1 T-unit, 1 S-node) in comparison with the syntactically more difficult T-unit “Maize seeds and seedlings are assumed to survive the winter only in southern European countries, such as Spain” (Pascher 2016: 2) (1 T-unit, 2 S-nodes (assumed, survive)).

Besides Oh (2001), there are other researchers (e.g. Yano et al 1994, Ragan 2006, Oh 2001, Rahimi 2011, and Kasgari 2018) who focused on the difference between simplification and elaboration. The most recent publication, Kasgari (2018), agrees with Oh’s (2001) description of simplified text as having “simpler syntax” and “simpler lexis”. Kasgari (2018: 7) presents the simplification strategy as “the elimination of intricate words and difficult syntactic structures”. When it comes to the origins of the concept of elaboration, Parker & Chaudron (1987: 110) describe the aim of this concept as clarifying the meaning rather than simplifying it. In line with this first description is also the most recent use of this notion, by Kasgari (2018: 8). He proposes that the aim is “expanding content understandability”. The strategy to achieve that goal is “through providing meanings of troublesome words [... and] rewording those sentences which contain intricate syntactic structures” (Kasgari 2018: 8).

Oh (2001: 69) used the umbrella term “input modification” to describe both elaboration and simplification, which consequently are the two types of input modification. These terms will be used in this thesis as well. The question of what type of input modification should be preferred will be discussed in the next paragraphs. Yano et al (1994), Ragan (2006), Oh (2001), Rahimi (2011), and Kasgari (2018) seem to be in favor of elaboration as the better type of modification. Rahimi (2011) lists three main disadvantages of simplification which lead to his approval of elaboration over simplification. He claims that the shortening of sentences hinders the learners’ acquisition of new syntactic items. Furthermore, he criticizes the distortion of authenticity, but only in context of simplification and not elaboration, which then leads to the students’ development of wrong reading strategies for the specific genre/task. The question if simplification or elaboration should be preferred to keep a text’s authenticity is addressed by Rahimi (2011) as well. While Rahimi (2011: 12) argues for elaboration over simplification by using the argument that simplification “distorts authenticity”, the same can be said about elaboration as well, since elaboration also simplifies the “subject to comply with a particular linguistic sequence” (Swaffar 1985: 18).

Another argument for preference of elaboration over simplification put forward by Rahimi (2011: 12) is that elaboration allows more “native-like complexity”. While this argument may be valid for general simplification, it is not applicable for this thesis which focuses on simplification of Primary Scientific Literature. PSL articles are not solely written by and for native speakers since the discourse community consists of non-native and native scholars of the specific field from all over the world. As mentioned in the chapter on the language of science, science authors strive to describe phenomena in a precise and concise manner (Gladon et al 2011: 116). Therefore, elaboration should not be overused, despite its support by many scholars. Gladon et al (2011: 158) described the phrase ‘economy of words’ which can be used to explain the balance between simplification and elaboration. They state that one should simplify a text by eliminating “words that do not have a function or are not concise”, however, one should “never sacrifice understanding for economy” (Gladon et al 2011: 158) though. Hence, if the information is essential, and the students should learn about it, one can use linguistic elaboration to clarify it, and present the new word, or concept through comprehensible methods, which will be described in the next section. However, unnecessary items should be deleted, or simplified.

When it comes to the latest studies dealing with the discussion about simplification versus elaboration, four studies have to be mentioned: Oh’s study from 2001; Li et al’s (2005) exploratory study; Rahimi’s (2011) research on syntactic elaboration techniques; and Kasgari’s recent publication from 2018. The four studies described here inspired on the one hand the decision processes made during the adaptation, and on the other hand, the design of the reading comprehension test.

The chronologically first article by Oh (2001) investigated the effects of simplification and elaboration on 180 Korean high school students. The students were also divided into high and low proficiency groups to examine if there could be correlations with proficiency levels and the two types of input modification. The students read six passages of one modification type or the original ‘baseline’ version. While Oh (2001) concludes that one should prefer elaboration over simplification, his results suggest no significant comprehension difference between those two. His main reasons for his preference are the more nativelike qualities of elaborated texts, which is less important in a Teaching English as a Foreign Language (TEFL) context. Since a great number of scholars within the global discourse community of science researchers are not native English writers, their text might not show nativelike features. Concerning the differences between low and high proficiency learners, “[n]o significant interaction was found between learner proficiency and modification type” (Oh 2001: 80).

Li et al (2005) copied Oh's (2001) methodology and examined 48 Filipino learners of English. Their results support the use of simplified over elaborated texts for improving comprehension. In contrast to Oh's (2001) results, they measured that both types of modifications helped students with lower proficiency more, while Oh (2001) stated that the effect of any input modification was bigger on high proficiency learners. Another difference to Oh's (2001) results is that in Li et al's study (2005), the total comprehension scores for the simplified passage were significantly higher than for the elaborated passage, whereas Oh (2001) stated that the higher scores for simplified texts were not significant.

Other studies investigated more specific aspects of input modification. Rahimi (2011) applied the research of input modification on syntax and executed syntactic simplification and syntactic elaboration on a text for engineering students. He states that using modification is very beneficial for learners of English for Specific Purposes in order to remove complex syntactic items that hinder the learners from comprehending the content (Rahimi 2011: 12). Similar to Oh's (2001) study on more general input modification, Rahimi's (2011: 15) results for syntactic modifications show that "students reading syntactically elaborated texts did not perform significantly better than those reading syntactically simplified texts". While these results do not support the use of syntactic elaboration over syntactic simplification, Rahimi (2011) still claims that elaborated syntax is better because only with elaboration students are exposed to new syntactic items and can learn them.

A more recent research by Kasgari (2018) focuses on input modification versus input flooding of non-congruent collocations. None congruent collocations cannot be translated literally into another language and are, therefore, harder to learn (Kasgari 2018: 2). This vocabulary-centered study shows that providing students with redundant paraphrases, as done in elaboration, and exposing them to many examples of a non-congruent collocation are equally effective (Kasgari 2018: 12). Kasgari (2018) does not only focus on elaboration for fostering comprehension, like Oh (2001), Li et al (2005) and Rahimi (2011) do, but Kasgari (2018) also shows that elaboration supports second language acquisition.

Considering the correlation of motivation and the two types of input modification, both elaboration and simplification can have positive impacts on motivation. According to Oh (2001) and Li et al (2005), simplification leads to a higher perceived comprehension. A high perceived comprehension means that students thought they understood more of the text and thought they were successful in comprehending the text. According to Mori (2002: 100), thinking that one was successful in reading a text, increases reading motivation. On the other hand, the process

of elaboration maintains a text's coherence (Kasgari 2018: 5) which is also linked with motivation and interest (Schraw & Lehman 2001: 36).

Ultimately the contrasting results of these studies allow the conclusion that both elaboration and simplification are valid methods to improve reading comprehension. The decision if simplification strategies or elaboration methods should be used has to be executed on a case-to-case basis. Important factors are the relevance and frequency of words or syntactic structures for the genre of Primary Scientific Literature as well as how these language features overlap with the teaching goals.

7. How to adapt Primary Scientific Literature – A Guideline

When it comes to introducing a guideline for adapting PSL, the suggestions put forward by Yarden and her colleagues and the theory on modification, both presented in chapter 6, are combined to make up the following steps.

7.1. Choose an article

The selection of a suitable article is a time-consuming process which influences each of the later steps immensely. In the beginnings of research on APL Yarden, Brill & Falk (2001) designed a whole curriculum based on adapted research articles. In their paper they describe three criteria for their selection of the four articles used in their experiment: Variety in subjects, experimental organisms and research approaches; a simple approach so that the students can follow the authors reasoning; and simple visualizations of the results (Yarden, Brill & Falk 2001: 191). While these criteria were originally created for a developmental biology curriculum they are also applicable to teaching physics, according to Langbeheim et al (2013: 23), and consequentially to all science teaching. This thesis, however, does not concern itself with a research-based curriculum, but with the use of Adapted Primary Literature in a coursebook centered curriculum. Consequently, some of the criteria mentioned earlier, such as variety of research approaches is not a criterion for the selection process.

While the criteria described above could be used as basis for the selection of an article, Yarden, Brill & Falk developed the curriculum already in 2001, at the earlier stages of APL research, and a more recent and more detailed list of criteria is depicted in Yarden et al's book *Adapted Primary Literature: The Use of Authentic Scientific Texts in Secondary Schools* (2015). The selection process included in their work consists of nine "nonsequential steps" (Yarden et al

2015: 84) which are ordered according to their importance for a successful adaptation from PSL to APL in the following section.

The first principle for choosing an appropriate article is that it “[c]omplements relevant curriculum content” (Yarden et al 2015: 85). This straightforward criterion for selecting a PSL article is listed first, since it is very important when using APL as part of a longer teaching sequence. The curriculum relevant to the Austrian biology CLIL classroom is the ‘Lehrplan für Biologie und Umweltkunde’ (2004) for the upper secondary level.

The next criterion is that the text “[a]nticipates students’ motivation to and interest in reading the text” (Yarden et al 2015: 86). Reading motivation and interest have been discussed in chapter 3 in detail already, and the research influences the selection of an article highly. Schraw & Lehman (2001) introduce three categories to promote situational interest, i.e. the kind of interest extrinsically triggered by a text. The three are: task-based, knowledge-based and text-based interest. The concept of ‘task-based interest’ is of less importance in our study, since the instructions for the reading comprehension task are kept to a minimum. What plays a vital role when adapting an article is ‘text-based interest’, which has already been mentioned in chapter 3. When it comes to choosing a text the most important source of interest is ‘knowledge-based’, which means that it is relevant to the reader’s background knowledge, for example the proximity issues discussed in the exemplification of the guideline. It is important to mention that the relation of prior knowledge and situational interest is not linear, but rather U-shaped (Schraw & Lehman 2001: 40), which means that neither very little information on the topic, nor a high amount of knowledge increase interest.

Another important principle for the selection process is that the PSL text “[m]atches materials to students’ prior knowledge” (Yarden et al 2015: 85). As in every teaching situation, one has to consider the students’ knowledge and beliefs on a topic before expanding the knowledge or correcting some misbeliefs. For understanding research in modern natural sciences, one also needs to understand experimental methods which draw on complex chemistry and biotechnology. One can either cut out these complicated processes during the adaptation process (Simensen 1987: 46) or choose an article with simpler methodology, such as monitoring and basic polymerase chain reaction (PCR). Another knowledge gap of high school students are statistics and their representations in graphs, if one does not pre-teach these skills, which are often not part of the curriculum, one has to choose a paper without complex diagrams and graphs. If they are not essential to the research, one can also delete them during the adaptation process (see chapter 7.3 on content modification)

When it comes to the methods of the study presented in the PSL text, the text should “[p]rovide a clear and logical research approach” (Yarden et al 2015: 86). According to Creswell, “research approaches are plans and the procedures for research that span the steps from broad assumptions to detailed methods of data collection, analysis, and interpretation”. Yarden et al (2015: 86) describe an easy-to-follow structure as “preferable” in the context of this study however, a logical research approach is of the most importance, since one of the goals of using APL is to increase scientific literacy and scientific thinking.

The next measurement for a suitable PSL article is that it “adjusts to the future use of the adapted text” (Yarden et al 2015: 84). The description of this criterion explains that the PSL article used as basis for the APL modifications should either fit to the curriculum if it is designed for teaching purposes or fit the research question if the APL article is solely used for research purposes (Yarden et al 2015: 84).

Another feature that has to be considered is that the text “[s]upplements the instructional sequence” (Yarden et al 2015: 85). This step in the selection process is closely related to the argument that students need prior knowledge to understand a text (Alexander et al 1994a: 325). The most effective way to integrate APL texts would be to incorporate them at the end of an instructional sequence, after the students have gathered enough knowledge to understand the text, and its methods and results.

A criterion which is rather hard to fulfill when selecting an article is that the article should “[e]stablish the credibility of the sources” (Yarden et al 2015: 85). Concerning the credibility, it is often hard to find articles published in the most prestigious journals, since they are most times highly field-specific and, therefore, presuppose a great amount of background knowledge.

The criterion that a text should “[p]rovide visualization to complement the results” (Yarden et al 2015: 86) can be seen as a two-sided sword. On the one hand, visuals help to understand the results, and on the other hand, they can be too complex for non-scientists. Many papers written in science use graphs to foster the understanding of the results, however even students at the tertiary level have difficulties interpreting graphs, as described by Ivanjek et al (2016) for the field of physics. For further research on visuals in Primary Scientific Literature see chapter 5.

The criterion that an article “[p]rovides a variety of research subjects, experimental organisms, and research approaches” (Yarden et al 2015: 86) only has to be included in the selection process if one teaches a whole sequence entirely based on APL and research-based learning.

Besides these nine criteria listed in Yarden et al (2015) and re-interpreted for the purpose of using APL in an Austrian 8th grade CLIL biology class, additional criteria are needed to care for the special setting within which this study is conducted.

10th criterion: The article does not demand too much linguistic background knowledge
Concerning prior knowledge, not only field specific methods and concepts have to be known, but also specific vocabulary. While one adaptation step is to reduce the jargon, and another one to write a glossary, not all biological terms can be exchanged or explained. Therefore, a paper that does not contain numerous acronyms, for example for genes or solutions etc. should be preferred.

11th criterion: The main information is presented in words

Research in modern biology often makes use of statistics to calculate and present its results. These numbers are then often also put into graphs. Both forms seem to hinder integrated language and content learning, since the focus should be on English and the content and not on mathematical understanding. While graphs can be used as support for illustrating the result, a result section consisting solely of statistical terms should not be the preferred basis for APL.

12th criterion: Length

One criterion that is not mentioned by Yarden et al (2015) is the length of an article. Some articles are over 20 pages long, including pictures and graphs, and this length does not support the reading motivation of students, neither does it help the speed of the adaptation process. One can of course cut out unimportant information, although one should implement this measure only to an extent that the results are still pure and fully supported by arguments and evidence (see chapter 7.3. on content modification).

These are the twelve criteria for selecting an appropriate PSL article. The next paragraphs discuss the adaptation process, the chosen article should be subjected to.

Once an appropriate article has been chosen, one can start with the adaptation process. The different steps described in the following chapter are sequential, however through constant re-evaluation of the intermediate products, some steps might need to be repeated several times. In general, one can say that the amount of adaptation needed varies strongly from article to article, and purpose of the adaptation.

A great amount of adaptation methods described in the next paragraphs are based on the theory of input modification, discussed in chapter 6.2. Other influences were the research on Adapted

Primary Literature by Yarden et al (2015), and other authors. Research by Khismawan & Widiati (2013) also influenced several of the following steps. This research studied the cognitive processes that underlie text adaptation. Their test subjects were student who were asked to paraphrase a text. Their perception of their own cognitive processes resulted in a list of 21 “cognitive paraphrasing strategies” (Khismawan & Widiati 2013: 141). This list was incorporated in the seven steps explained here. While this list focuses on the process of paraphrasing, it can be modified towards the process of adaptation from a PSL article to an APL article. The genre-specific features of PSL discussed in the chapters on English in academia and English as a scientific language described in chapter 5 also have to be taken into account when creating a theoretical guideline for the production of APL.

In general, adapting and simplifying texts to increase the new audiences’ reading comprehension consists of three main “principles of control: control of information, control of language, control of discourse and text structure” (Simensen 1987: 45). Control of information is discussed here under the term ‘content modification’, control of language as ‘linguistic modification’, control of discourse as ‘highlighting scientific communication’ and control of text structure as ‘structural standardization’. When adapting a text, one quickly realizes that these categories are not distinct. For example, if one changes a word (lexical item) the content automatically also changes and vice versa. Therefore, one has to check regularly, how one adaptation step influences all of these four categories.

A quick summary of the steps is presented in this paragraph. The first step is to read and comprehend the text as a whole. Secondly, one has to determine which content is essential for the research article and which distracts the reader from the important content. Next, one should identify the keywords which are important for comprehension and elaborate on these words within the text or as part of the glossary. Paraphrasing not essential scientific and academic vocabulary is also part of lexical modification. The next phase for adapting a text for better comprehension is to reduce syntactic complexity within t-units and reduce the number of grammatical metaphors through changing them into congruent structures. After that one should highlight the communicative structure of the scientific discourse through the incorporation of a background section outside of the main text. Lastly, the adaptor rewrites the abstract and adjusts the structure of the text so that it fits the norms of Primary Scientific Literature.

The following seven steps are intended to be a guideline for adaptors, specifically for people who need to adapt Primary Scientific Literature for high school students whose first language

is not English. The approach presented in this chapter will then be applied in chapter 9.1 in an Austrian CLIL context.

7.2. Comprehending the PSL

The first step of adaptation is a rather obvious one, namely reading the paper. Khrismawan & Widiati's (2013: 143) subjects mentioned that they had always read the whole text first before starting paraphrasing. Their reason was to get a basic overview of the topic of the text and determine its main ideas (Khrismawan & Widiati's 2013: 147), i.e. they read for general comprehension. Khalifa & Weir (2009: 45) refer to this type of reading comprehension as 'global comprehension' which describes "how the ideas in the whole text relate to each other and to the author's purpose" (Khalifa & Weir 2009: 45). After general comprehension, the authors of the adaptations in Khrismawan & Widiati (2013: 143) focused on the sentence level and even smaller units, i.e. specific comprehension. They automatically read groups of words and phrases as chunks that function as a logical unit, and later adapted unit by unit. For the adaptation for this study, the chunks mostly consisted of one T-unit, as discussed later, in the section on syntactic simplification.

Concerning visual representation of data, for example diagrams, Cromley et al (2010: 59) state that more proficient learners spend more time studying diagrams in a text, which increases overall comprehension. Furthermore, Cromley et al (2010: 60) suggest that high school students might not spend much effort on diagrams, because they stick to the form of data presentation they are more used to, i.e. written text. Just as every other form of comprehension, diagram comprehension has to be practiced, therefore, one should keep the diagram in the APL, but add textual description into the ongoing text to support overall comprehension. This suggestion leads us to the next step of adaptation, namely content modification.

7.3. Content modification

According to Honeyfield (1977: 433), there are two ways of simplifying content. Either a complete rewriting of the text, or an abridgement: "Here a simplified [version] follows the language and order of the original more closely but omits whole passages considered to be less important" (Honeyfield 1977: 433). For this thesis, an abridgement is the best option since the goal of APL is to stay as close to the original article as possible. Rewriting a whole journal article would compromise the authenticity of the PSL text. Since APL can be seen as a tool for bridging the gap between coursebook texts, JRVs and PSL, a complete rephrasing of the article

would end up being closer to journalistic reported versions of a science text and not resemble Primary Scientific Literature anymore.

Concerning the question of how to simplify an article's content, one should keep the use of the APL text in mind. If it is used to show students the complexity of a research method, one cannot simplify the protocol of this method, by cutting out less important steps, such as waiting times and cool down periods of solutions. However, if the teacher wants the results to be the main focus of the APL article, it helps to improve reading comprehension through simplifying the method section by focusing on the main principle (Yarden et al 2015: 91). However, one has to differentiate between summarizing, which decreases the word count, and modification, which should diminish the cognitive load. Still, summaries of some sections might be beneficial for highlighting other sections, since lower word count "very likely decreases semantic equality" (Khismawan & Widiati 2013: 147). For example, if needed, one can summarize the 'methods' section, and thereby shorten it, so that readers do not give it the same importance as other sections (see also chapter 7.4). For general content modification one can transfer suggestions from creating graded readers into APL research. Simensen (1987: 46) summarizes that many guidelines instruct cutting out information that is irrelevant or marginal. In graded readers, these are subplots and minor characters. In APL it is highly dependent on which section of the PSL article is under adaptation. Hence this will be discussed in chapter 7.4 where the adaptation of the single genre-specific sections of PSL will be examined in more detail.

Content modification does not always mean reduction; it can also mean supplying additional information to highlight or clarify content. When it comes to choosing what is important one has to be careful not to focus on marginal information, since this "may have a deleterious effect on comprehension" (Schraw & Lehman 2001: 39). Elaborating content to make up for the lack of sufficient background knowledge, and provide informational completeness, does not only ease comprehension, but also increases interest in the text (Schraw & Lehman 2001: 40). Despite the importance of additional content to make up for missing background knowledge, one has to be aware of the danger of too much "density of information" (Simensen 1987: 47), which can overwhelm learners (Tweissi 1998: 200). The "changing [of] information sequence" (Khismawan & Widiati 2013: 145) also belongs to strategies of general content modification, since the adaptor highlights specific parts of the content by changing its order and tries to help the students identify the main ideas by sequencing them. Additionally, re-ordering information could lead to better passage coherence and consequently improve reading comprehension (Singer & O'Connell 2003: 623).

When it comes to the adaptation of content, one has to be careful not to compromise any of the results. Most scientific discoveries are presented in journal articles. The journals this Primary Scientific Literature is published in all have copyright policies. So called open access journals allow free distribution of their publications, others do not allow it. Therefore, it is important to read the copyright agreement of the article and journal used for adaptation.

7.4. Structural standardization

Primary Scientific Literature has a clear, almost formulaic structure, which has to be presented to the students through Adapted Primary Literature. Even when the structure slightly differs from the widely recognized version, one can adapt the section titles and contents so that it fits the formulaic version of a research paper.

The standard arrangement of sections helps the scientist-reader to find the information he/she is looking for more easily (Gross & Harmon 2010: 86). Research articles have a very conventional format: Introduction, Methods, Results and Discussion (Hyland 1998: 15). Gross & Harmon (2010: 86) describe each section briefly: The title “conveys the gist of the main new knowledge claim”, and the abstract “expands on the title”. The introduction “places readers in the scientific context”, while the methods and materials sections, as the headings suggest, “explain choices behind methods and materials”. The results sections “display the data generated” and the discussion section “interprets and qualifies the data”. Lastly, the conclusion “reiterates the central new claims and addresses future research”. Additionally, “references that identify sources the authors have relied on” and “acknowledgements that note personal or financial assistance”. Yarden et al (2015) comment on adaptation processes for each section independently, except for references and acknowledgements which will not be adapted in any way. Yarden et al’s (2015) research will be complemented by other findings in the field of content modification in the following seven sub-chapters.

7.4.1. Title

Yarden et al (2015) mentions that one issue with title adaptation is the same as in every other section, the problem of jargon. Hence titles also need slight modifications while the message of presenting the main findings should be retained (Yarden et al 2015: 88). Contrastingly, Lin & Wilbur (2007:) suggest that one possibility to simplify a title is to remove the phrase after the colon, or consecutive dash, i.e. the subtitle, completely. Lewison & Hartley (2005) estimated that 11 % of all papers in the field of biology have colons in their titles, while titles with question

marks are comparatively rare in scientific articles. Additionally, they found a correlation of authors working on the article and the length of the title. The fact that the original paper used for this study was written by a single author goes in line with Lewison & Hartley's (2005: 563) results which suggest that colons are more often used by single authors. One additional reason for keeping the whole title is that, in general, students prefer titles which have colons (Lewison & Hartley 2005: 563).

7.4.2. Abstract

There is extensive research on the writing and comprehension of abstracts. Yarden et al (2015: 88) suggest rewriting the abstract completely, since this is needed after the extensive modifications executed on the main text so that the essence of the text is represented in the abstract. Concerning the structure, one should retain it so that it still imitates the main paper structure (Yarden et al 2015: 88). Since the abstract has a higher degree of modification, it is important to follow the rules of writing a scientific abstract proposed by authors like Lebrun (2011).

7.4.3. Introduction

The first section of the main text is most commonly termed 'Introduction'. The purpose of this passage is to "provide information about the research background" (Marwan 2017: 110). Swales's (2004) CARS ("create a research space") model identified three moves typical in introductions of research articles. A 'move' can be described as "a functional unit within a larger, more-or-less ordered sequence" (Atkinson 2013: 2). Starting with "establishing a territory", the introduction continues with "establishing a niche" and finishes with "presenting the present work" (Swales 2004: 230). All three moves are key features of the introduction and one should maintain the structure of this section as it is (Yarden et al 2015: 89). Koeneman et al (2013) come to a similar organization of the introduction section when applying an argumentation analysis framework especially designed for PSL articles. They studied pre-university students' ability to identify the elements of argumentation used in Primary Scientific Literature. The introduction consists of the 'motive', which "explains the reason for conducting the investigations and frames the research for the non-expert" and the 'objective', "which explains in what direction the efforts of the researchers will be leading" (Koeneman et al 2013: 2014).

Concerning the adaptation process, Yarden et al (2015: 88) mention that one should keep the purpose of the introduction in mind, although, the target audience is important as well. The knowledge gap between the old target audience, i.e. scientists, and the new one, i.e. high school students, should be bridged through adding background information and a list of essential terms. The list of essential terms is basically the glossary box. Most of the terms explained in the glossary are derived from the introduction section, since this passage possesses “most of the potential problematic concepts and vocabulary” (Koeneman et al 2013: 2015). When it comes to the background information needed, in HAPL, this content is put in a narrative text outside of the main text. Furthermore, Yarden et al (2015: 89) suggest elaborating on studies mentioned in the introduction, but “only those that are essential for understanding the message of the specific article”. The last recommendation for adapting the introduction, by Yarden et al (2015: 89), is to finish this section with describing the objective of the study, possibly in form of a research question. This recommendation is in agreement with Swales’s (2004) move structure model.

7.4.4. Methods

The methods section varies the most between different disciplines (Swales 2004: 219). Therefore, universal adaptation foci are hard to determine. Swales (2004: 220) identified two main types of methods sections: clipped texts and elaborated texts. The clipped versions presuppose a lot of background knowledge, do not exemplify or define terms and use many acronyms. In contrast to that, elaborated versions resemble the elaborated texts mentioned in chapter 6.2 on input modification theory: they provide background knowledge, illustrate, define, and exemplify terms and show a wide range of linking phrases. While research papers in the humanities often contain elaborated methods sections, this is not the case for natural sciences with their clipped versions. However, the differences between the sub-fields lead to many exceptions of this ‘rule’ (Swales 2004: 223). Despite the differences, the purposes of the methods section are usually the same. They “describe what is done to answer the research question, describe how it is done, justify the selection of design, and explain how the results are analyzed” (Marwan 2017: 110). Methods sections need to be very detailed since they could be used to replicate the study. Additionally, the methods should clearly justify the conclusions drawn from the results (Marwan 2017: 110). When it comes to the adaptation of the methods section, only the “main principle of a method” should remain, while other details, such as solution compositions, cooling down periods etc can be eliminated (Yarden et al 2015: 89). Since the APL readership is not supposed to replicate the experiment, there is no need to keep

these comprehension-hindering details in (Yarden et al 2015: 91). Concerning syntactical characteristics of the methods section, Gross & Harmon (2010: 190) mention that the passive voice is particularly often used in these passages. As discussed in chapter 7.6 on syntactic simplification, since passive structures are such a key feature of research papers, one should not transform them into active constructions.

7.4.5. Results

Marwan (2017: 110) states that the results section should present the research findings “clearly” and “objectively” with the help of graphs and tables, yet, the author can still emphasize some findings over others. While Marwan (2017) excludes all discussion from the results section, Gross & Harmon (2010: 42) have another view: “the results section emphasizes results but contains some discussion, while the discussion section emphasizes discussion but restates some results”. The extent of the influence of the discussion section onto the results section and vice versa varies between the disciplines (Gross & Harmon 2010: 42). The argumentation analysis framework by Koenen et al (2013) mentioned earlier determines three elements which can appear in the results section as well as the discussion section: supports, counterarguments and refutations (Koenen et al 2013: 2014). Difficulties students face when reading the results sections were identified by Yarden & Falk (2009) and classified into “coordination practices”. Connecting the data presented in the results with the theory mentioned in the introduction section and the experiments of the methods section seemed to be one coordination practices students had difficulties with when reading the results section (Yarden & Falk 2009: 360-361). Concerning the adaptation of the results section, Yarden et al (2015: 91), again, recommend omitting peripheral findings which do not directly answer the research question. Regarding the missing background knowledge, one should either eliminate complex graphs, or repeat the information through a medium students are more used to, i.e. text. (see content modification 8.3.)

7.4.6. Discussion and conclusion

The purpose of the discussion section is that the “authors elaborate on their achievement by comparing it with work done earlier by others” (Harmon & Gross 2010: 48). The difference between the results section and the discussion section is that the former generates data and only includes the “most immediate inferences”, while the latter “transforms those facts into an argument” (Harmon & Gross 2010: 52).

Research articles, in general, encompass the content structure of an hour glass, with the introduction presenting a broad overview of the topic, while methods and results sections refer to the particular study at hand. In the discussion section, the content widens up again, as the scientists contextualize their findings with previous research, mentioned in the first section (Swales 2004: 234-235). While Gross & Harmon (2010: 42) mention that results and discussion content can overlap, Swales (2004: 235) states the same for elements of discussion and conclusion. Koeneman et al (2013: 2014) support this view in claiming that main conclusions and implications are already part of the discussion section. The sectioning in discussion and/or conclusion can vary within even a single journal, according to Swales (2004: 235). If the conclusion is a separate section, it contains “the most significant message”, the finding that relates to the research question and other significant, or unexpected outcomes (Marwan 2017: 110). Harmon & Gross (2010: 58-59) recognize some parallels between the anticipated claims and impacts of the introduction and the fulfillments of these anticipations in the conclusion.

When it comes to the adaptation of the discussion and conclusion section, Yarden et al (2015: 93) mention that one should not forget to eliminate the discussion of previously deleted unimportant results. If typical moves of the discussion or conclusion, such as implications for future research, or limitations of the study, are missing in the PSL one should add them for the APL. Possible controversies and the argumentative aspect of a discussion section can be highlighted (Yarden et al 2015: 93) However when creating Hybrid Adapted Primary Literature, this can also be done in the narrative text.

7.4.7. Other additions

Lastly, Yarden et al (2015: 93-94) suggest three additions which can be included in an APL article. As mentioned in the chapter on lexical modification, a glossary with definitions and explanations of keywords and terms should be added. This can be done in the margin, before or after the main text. If one teaches the APL text through the conversational approach (see chapter 6.1), one can also add questions for students “to refine a certain point being made in the text and to challenge students to think about the research from multiple perspectives” (Yarden et al 2015: 94). The third addition mentioned is a paragraph “with an explanation of the contribution, relevance and importance of the work described in the article which [should] give a global view of the research and its importance” (Yarden et al 2015: 93). As already described in chapter 6.1 on the historical development of APL, this additional paragraph can help the students connect the results with the conclusions, identify the motive of the authors for putting

so much time and effort into the research (Shanahan et al 2009: 24). The narrative text should also highlight the communicative aspect of science in that the author is introduced and the research is not presented as absolute knowledge, but as a possibly controversial issue with different parties which draw different conclusions from the same results. The background information needed for presenting the article within the context of scientific discourse can be deduced from reviews of the article, interview, press releases and other material (Shanahan 2009: 23).

After adapting the content, the next step would be the simplification of single words and phrases, i.e. lexical modification.

7.5. Lexical modification

In chapter 5 it is mentioned that a Vienna-based study (Adebesin 2015) discovered that all participating high school students identified the reason for being bad in science was due to their lack of academic vocabulary knowledge. The difficulties with lexis of Primary Scientific Literature, mentioned in chapter 5, can be reduced through methods of lexical modification, starting with identifying keywords and academic and scientific terms.

7.5.1. Identifying keywords and terms

Keywords are important words that students need to understand in order to grasp the main concepts of the PSL article. Often a list of keywords is included after the abstract, however, for learners of the English language more keywords should be determined and explained through methods discussed later on. It is also suggested that, in contrast to other genres, one should not use synonyms for these important key terms (Lebrun 2011: 10). Repetitions of these keywords emphasizes their importance and lessens the demand on the memory (Lebrun 2011: 10). Cervetti et al (2015: 177) suggest adding explanations for scientific words that also have an everyday meaning to counter the high amount of polysemous words in scientific texts. Not only key words should be identified, but also academic and scientific lexis (see chapter 5).

As mentioned in the chapter on input modification theory, there are computer programs used for adapting specific genres. Kandula et al (2010), describe the functions of different programs used in natural language processing very transparently, and parallels to manual simplification can be found. These parallels concern mainly the step of syntactic simplification, however, lexical simplification is mentioned as well. Kandula et al (2010) offer instructions of how to simplify medical records for the general public. They describe the identification of “difficult”

words as the primary step of simplification (Kandula et al 2010: 366). In the research on graded readers, it is common to start with categorizing vocabularies into frequent words (Fierling 2011: 26), i.e. the most often used 2000 words (Wan-a-rom 2008: 43), that should already be known by students, with the help of frequent word lists. The ideal percentage of known words is 98% (Wan-a-rom 2008: 44). However, “when one cannot stay within the word lists, [...] it is important not [to] contort the message to avoid using the most appropriate word” (Waring 2003: 10). Since Primary Scientific Literature uses an academic discourse, academic word lists are helpful when identifying vocabulary items considered to be academic English (see chapter 5).

7.5.2. Using glossaries

Yarden et al (2015: 145) suggest the use of glossaries following the APL article, or at the margin of the article, to explain scientific terms which might not be known by high-school students. The earlier identified keywords and scientific and academic lexis should be highlighted and through synonymy or paraphrases explained in a glossary box outside of the main text. The probably previously unknown words should roughly comprise roughly two percent of the text, as suggested by Wan-a-rom (2008: 44). Khristawan & Widiati (2013: 144) also mention the use of dictionaries and thesauri to check for the meaning of a term and its synonyms. Through thesauri and dictionaries, one can create a glossary outside of the main text. While some of the more academic and scientific vocabulary can be paraphrased within the text, the most essential terms are paraphrased outside of the text in a separate glossary box.

A rather simple strategy is the replacement of words with synonyms (Kandula et al 2010: 367), i.e. “a word or expression which means the same as another word or expression” (Sinclair 2006: 1470). This approach is used rather rarely, since real synonyms are extremely scarce, especially when seen within the co-text (Pearson 1998: 168). Despite this difficulty, the use of near synonyms is “one of the most productive processes in the paraphrasing tasks” (Khristawan & Widiati 2013: 142) and also lexical modification. Synonyms are mostly used for some low-frequency words. It is important that the meaning of the sentence is not changed when replacing a word with a synonym. Additionally, one has to check if the grammatical application is the same for both the new and the old synonym. Synonyms need to be equivalent in meaning and in usage (Pearson 1998: 170). Another important factor when using synonyms is the dependency of meaning on the context. Fløttum (2007: 7) mentions that language analyses of science texts should keep the connection of meaning and context in mind, especially in the field of science with the many sub-disciplines and the specific use of words. Carter (1987: 19)

mentions that synonyms, while not being “totally interchangeable in all contexts” still should not change the “propositional meaning of the sentence as a whole”.

While Carter (1987) describes stylistic differences as limiting the use of synonyms, Adapted Primary Literature should use these levels of style and register to foster comprehension, by selecting a synonym which is used more frequently and in less genre-specific contexts, i.e. choose less academic and scientific terms (see chapter 5). Nevertheless, thesauri, dictionaries and word lists do not always contain applicable synonyms that do not change the overall meaning of a sentence (Carter 1987: 19), therefore sometimes the adaptor has to paraphrase words in order to simplify, i.e. replace a word with a phrase (Honeyfield 1977: 433).

7.5.3. Paraphrasing

Kletzien (2009: 73) defines paraphrasing as “putting the content into one’s own words”. To give a more detailed definition of paraphrasing, one has to contrast it with terms that tend to be used interchangeably but are not the same. Paraphrasing differs from re-telling in that it does not prefer using the same words as the original, as is the case for re-telling (Kletzien 2009: 73). The differences to summaries are that paraphrases do not categorize the information according to their importance and do not shorten the text, in contrast, they often increase the word count (Kletzien 2009: 73). General cognitive steps in the process of paraphrasing are described by Khrismawan & Widiati (2013). Since the subjects of their study are graduate students in the teacher program, the cognitive processes can be applied to adaptors who want to paraphrase words for a scientific article as well.

Khrismawan & Widiati (2013) list several steps for paraphrasing. The first step is to read and comprehend the text as a whole (see chapter 7.2). Then the subjects of this study chose the terms they wanted to paraphrase. This was done paragraph by paragraph, categorizing parts into important or unimportant, while at the same time selecting key words that should not be replaced. In our context, these words would be part of the glossary. The next phase for paraphrasing a text for better comprehension is to paraphrase step by step through separating the information of the original text into chunks and rephrasing it. Khrismawan & Widiati (2013: 142) also mention “strategies such as rearranging information sequence, changing the syntax, using synonyms, and revising the paraphrase to improve the wordings”. After this time-consuming phase, their subjects combined the chunks into a text again and checked if the new text had the same meaning as the original one (Khrismawan & Widiati 2013: 141- 142). While Khrismawan & Widiati’s (2013) subjects had to paraphrase a whole text passage, the adaptor

of a PSL text needs to use this method mainly on short chunks of language. The adaptors do not always have to come up with their own paraphrases. Especially in the case of paraphrasing scientific and academic terms, definitions from thesauri and dictionaries can be used. Nevertheless, a paraphrase of a complete paragraph, as done in Khrismawan & Widiati (2013), is needed when adapting the abstract, according to Yarden et al (2015: 88).

After lexical modification, simplification of syntax is the fourth step of the adaptation process.

7.6. Syntactic simplification

The adaptation step of syntactic simplification is closely linked to the genre-specific features of PSL described in chapter 5. It is also intertwined with the previous stage of lexical modification, since syntactic competence itself is greatly linked to knowledge of lexis and they both influence each other when comprehending reading (Rahimi 2011: 12).

While in the end the reduction of syntactic elements and of grammatical metaphors are the main methods of syntactic simplification, there has been much research which indirectly influenced the decision to focus on these two measures. Even though the methods presented here are not applicable to the creation of an APL text, they are mentioned due to their importance for the field of syntactic simplification.

There is much research on syntactic simplification done in the field of computational natural language processing (Yimam & Biemann 2018, Sevens et al 2018, Xu et al 2015, Perera & Kosseim 2013, Lin & Wilbur 2007, Jonnalagadda & Gonzalez 2010). The language processing programs presented in these studies aim for improving information instruction and discourse analysis, and not “human readability” (Jonnalagadda & Gonzalez 2010: 351). Only Kandula et al (2010) used Jonnalagadda & Gonzalez’ simplification tools for natural language processing for improving reading comprehension. While they still used programs and databases for simplifying medical texts, many of the steps can be done manually as well.

Their first step for syntactical simplification is to identify sentences longer than ten words which should be simplified (Kandula et al 2010: 368). If the sentence is a compound or complex sentence one should split it into two sentences and add a coordinator, since complex sentences with adjective clauses and compound sentences (with more than one predicate) are difficult to comprehend for students (Keshavarz et al 2007: 24). Lebrun (2011: 16) also suggests examining all sentences that exceed 40 words for clarity and after identifying its purpose “break it down into smaller sentences” (Lebrun 2011: 16). The next step is to check for unnatural language,

which is, as already mentioned, a great fear about simplification of some researchers (Rahimi 2011, Oh 2001). One has to analyze the split sentences so that they are not too short (under 7 words) and that the sentences and grammatical items are linked (Kandula et al 2010: 368). The task of checking for the outcome to “be a reasonable English sentence” (Kandula et al 2010: 368) is accomplished by the program through comparing it with a big language database. While it is questionable if the proposition of Kandula et al (2010) that sentences should consist of seven to ten words after simplification is desirable and applicable for medical records, it is definitely not in line with the grammatical key features of PSL articles mentioned in chapter 5.

The manual adaptor of PSL articles has to rely on his experience with the English language for this last evaluation of the syntactically simplified sentence. While this approach seems easy and efficient, there are other units of syntax which can be used for syntactic simplification, beside the sentence, namely T-units.

7.6.1. T-unit analysis

While the aforementioned research suggests focusing on a sentence level in determining syntactic complexity of a text, there are shorter syntactic units which can be used as the basis of syntactic simplification, namely t-units. T-units, or text units, have been defined in chapter 6.2 as consisting “of a main clause and every subordinate clause or even non-clausal structures that are attached to the main clause or embedded in it” (Hunt 1964: 20-21).

Admittedly some disadvantages of using t-units to investigate syntactic complexity can be identified and are listed in Bardovi-Harlig (1992). She suggests that it is better to focus on a sentence level and not on the t-unit level, since coordination and subordination are also indicators of complexity (Bardovi-Harlig 1992) and are not incorporated in t-unit analysis. Another disadvantage of the “t-unit analysis [is that it] artificially divides sentences that were intended to be units by the language learner, imposing uniformity of length and complexity on output that is not present in the original language sample” (Bardovi-Harlig 1992: 391). While this is a valid critique, the characteristic of PSL texts of having a high amount of complex and compound sentences leads to the conclusion that a t-unit analysis to evaluate the text’s syntactical complexity would be more accurate.

In contrast to Bardovi-Harlig (1992), Lotfipour-Saedi (2015) suggests in a recent paper the reduction of the number of words within a t-unit and not sentences. But not only the amount of words matters, also their type and syntactic role. In his paper Lotfipour-Saedi (2015), discusses the “variations in the cognitive load of words” (Lotfipour-Saedi 2015: 11). Deleting elements

that bear substantial cognitive load is equivalent to simplifying a text's syntax. As an example of increased cognitive load one can look at modifiers, which have more cognitive load due to their "invisible predication relationship they strike with the items they modify" (Lotfipour-Saedi 2015: 11), i.e. their dependency of meaning and grammatical connections with other words of the T-unit. In a more recent study Lotfipour-Saedi et al (2018) research the cognitive load of different textual features, making cross-generic comparisons, i.e. comparing the different sections of research articles, and cross-disciplinary comparisons, between research articles of Applied Linguistics and Biology. Reducing the cognitive load leads to an increase of reading comprehension. Lotfipour-Saedi et al (2018: 47-49) identified five textual features to be cognitively demanding:

"1- Magnitude of Text-units (T-unit) [MOTU] in terms of the number of the words contained in each T-unit". As already mentioned, a T-unit is defined as "a piece of language between two full stops", therefore, MOTU describes the number of words within these two stops. If the MOTU increases, it affects the text processability which leads to more cognitive load, and consequently, decreases the text's comprehensiveness. Reducing this figure is one method of increasing comprehension.

"2- Physical distance between the main verb and its satellite elements". Roughly put, satellite elements are nouns or noun phrases that alter the meaning of a verb. The number of words between these satellite elements and the sentence's main verb is the unit which describes 'physical distance (PD)'. The reason PD increases the cognitive load is that it is harder for the short-term memory to process meaning, if the words forming this meaning are disrupted by intermediate structures. To exemplify this concept, one can look at the sentence: 'Physical distance, which is six in this case, complicates a text.' The six words between the main verb "complicates" and the noun phrase "physical distance" are "which is six in this case" and result in a PD of 6. In contrast to that, the physical distance between "complicates" and "a text" is zero. Therefore, by eliminating the clause "which is six in this case" one can reduce the PD and increase comprehension.

"3- Degree of embeddedness [DE] of the main verb in each T-unit". This is determined by the number of words before the verb, since perceiving the semantically important unit of the main verb at the very end of the T-unit increases its cognitive load.

"4- Magnitude of X satellite elements [MOX] (i.e. noun phrase appearing before the verb) of each T-unit". There are six different types of satellite elements, depending on their position and

the type of verb they modify. As explained in this quote, X-satellite elements are all noun phrases which are semantically connected to a verb of a T-unit and appear before said verb. It is suggested that a higher number of X-satellites also leads to lower comprehensiveness.

“5- Magnitude of Y satellite elements [MOY] (i.e. noun phrase appearing after the verb) of each T-unit” (Lotfipour-Saedi et al 2018: 47). Same as for X-satellite elements, a larger MOY equals more cognitive load.

Reducing these five features will be the main aspect of syntactic simplification for this study. Concerning the results of Lotfipour-Saedi et al’s (2018) study, the cross-generic aspect, i.e. differences between sections of journal articles, will be mentioned when each section of a research article is described in detail. Beside Lotfipour-Saedi et al’s (2018) five textual features, they of course also mention that “in academic texts some other textual forms such as grammatical metaphors or syntactic elements among many other factors may contribute to difficulty of texts” (Lotfipour-Saedi et al 2018: 54).

7.6.2. Grammatical metaphors

Another increase in cognitive load can happen due to a double function within a single word. The systemic-functional approach describes the instances above as grammatical metaphors, first defined by Halliday (1998). Unmarked structures used in everyday speech and writing are called congruent. In contrast to that, non-congruent structures consist of the metaphorical realization of meaning. Banks (2003: 127) described and exemplified the most common form of grammatical metaphor, nominalizations, this way:

Processes are congruently encoded as verbs; when they are encoded as something else, such as nouns, we have a non-congruent form, and this constitutes a grammatical metaphor. Thus, *grammatical metaphor evolved* is congruent, while *the evolution of grammatical metaphor* is non-congruent, and therefore a grammatical metaphor for the congruent form.

The systemic functional grammar was introduced by Halliday in 1985 and is the basis of the concept of grammatical metaphor. He also introduces different categories of grammatical metaphors. On the one hand there is the ‘interpersonal metaphor’ which is again categorized into ‘metaphors of mood’ and ‘metaphors of modality’; on the other hand, the general category of ‘ideational metaphor’ with its two types of ‘logical metaphor’ and ‘experiential metaphor’. Since interpersonal metaphors do not have much effect on scientific language and its modifications, they will not be discussed here. Ideational metaphors, however, play an important role for presenting scientific discourse (Ezeifeka 2015: 3). Logical metaphors show

relations, be it consequential or temporal, within clauses or groups of clauses (clause nexus) (Devrim 2015: 18). This phenomenon is intertwined with the experiential metaphor which describes that, for example, a noun takes over the typical function of a verb: describing a process. There are other forms of experiential metaphors (Ezeifeka 2015: 4), although, the most common in general and in biology texts is nominalization: “a process realized by a verb may be coded as a [...]a noun/nominal group”.

As another example of a “downgrading” of a semantic unit onto a “lower” lexicogrammatical structure, can be compressing the information delivered by several clauses into a single clause. All these grammatical metaphors result in a “shorter yet comprehensive variant” (Ezeifeka 2015: 4).

Devrim (2015: 19) came to the conclusion that a congruently written text is easier to comprehend, however grammatical metaphors are highly associated with science discourse. Still, the tension between comprehensibility and authenticity has to be discussed for each case of grammatical metaphors independently, and a simplification of a non-congruent structure into a congruent one has to be decided on a case-to-case basis. For some important terms one can remap the process found in the form of a noun in the glossary, as a congruent paraphrase.

It has been mentioned that grammatical metaphors, especially ideational metaphors are prevalent in EAP. The reason for this difference lies in the importance of objectivity in science and other disciplines. Additionally, a shift from single or multiple experiences to a theory is achieved through grammatical metaphors which create a sense of absoluteness, while every theory actually still has the potential to be disproven (Reeves 2005: 45).

One aspect of cognitive load, i.e. readability, is the depth of embedded-ness, which means the place a word has in the t-unit hierarchy. Being low in the hierarchy means to be dependent on others, i.e. adverbs, whereas being high in the hierarchy means being less embedded and more independent from other constituents of the t-unit.

Other syntactic features such as the use of non-finite verbs and participles to present only the process and not its participants can also be found very often in academic texts (Lotfipour-Saedi 2015: 13), because “the writer wants to focus on the processes under discussion and is not interested in specifying the participants” (Lotfipour-Saedi 2015: 13). Besides Lotfipour-Saedi’s (2015) claim that these non-finite forms are harder to comprehend, they need to be kept in the article, since they are an essential feature of scientific syntax to which students should be exposed in their schooling.

In addition to transforming grammatical metaphors, reducing the magnitude of T-units etc., the issue of deixis is of importance for reading comprehension. Waring (2003: 10) states that anaphora and cataphora are often problems for the development of language learners. These grammatical structures pose, besides overload, the danger of ambiguity. Concerning anaphora, i.e. backward referencing using pronouns, one can clarify the meaning by using the referent instead of the pronoun. The same is the case for cataphoras, i.e. forward referencing (Waring 2003: 10), since a linear sentence structure is easier to comprehend (Lotfipour-Saedi 2015: 9). Waring's view on pronouns goes in line with Lebrun's (2011) suggestions for scientific writing. He warns writers of scientific articles about the danger of ambiguous pronouns, due to spatial distance between the candidate and the pronoun (Lebrun 2011: 7). His suggestion is to "Conduct a systematic search for each of the following pronouns in your paper: 'this,' 'it,' 'they,' 'their,' and 'them'" (Lebrun 2011: 7) and check for possible ambiguities (Lebrun 2011: 7).

To conclude, syntactic simplification can be executed through various approaches. In an educational setting, the approach of computational natural language processing cannot be considered, since discussing the complications and processes involved goes beyond the knowledge of teachers, who mostly also do not have the resources to use this method. On the other side of the complexity scale concerning syntactic simplification is Honeyfield's (1977) Kandula's (2010), and Kesharvarz' (2007) suggestion of simply splitting up sentences longer than ten words. The approach this paper adopts lies in the middle, concerning its difficulty of application. Decreasing the cognitive loads of t-units can be used as the core concept of simplifying the syntax of Primary Scientific Literature. The reduction of the five complexity markers postulated by Lotfipour-Saedi et al (2018) should lead to better reading comprehension. When it comes to the topic of grammatical metaphors, while increasing the cognitive load, this structure is prototypical for Primary Scientific Literature, and therefore, the transformation of grammatical metaphors into congruent structures have to be considered on a case-to-case basis. When it comes to nominalizations which often result in a less frequently used term, one has to take both syntactic and lexical aspects into account.

7.7. Highlighting Scientific Communication

As discussed in chapter 1 and 2, communication is an important aspect of CLIL teaching. Following the CLIL matrix, one should emphasize the communicative purpose and nature of PSL. Scientific communication, i.e. the communication between scientists, differs from general

communication in the points mentioned in chapter 5 on the features of PSL. Some of the communicative aspects can be highlighted to foster students' understanding of the production and reception of new scientific knowledge.

One aspect of scientific communication is the relationship of the interlocutors and their appearance in the text. The researcher's use of his/her own voice in his/her text is an important characteristic of scientific writing. A very prominent example of the use of voice is the wide use of passive structures, especially in the natural sciences (Gray 2015: 111). Since it is such a characteristic feature of PSL, one should not highlight the presence of an author through transforming the sentences into active structures. As Cheong (1987: 41) put it: "Since the research and experiments of the scientist should occupy the centre of his work, frequent intrusions of his personality are not permitted". However, comparable to the outsourcing of paraphrases into a glossary box, one can outsource the presence of the author to a separate section from the main text. Shanahan et al (2009) terms the genre that includes an APL text plus a narrative text introducing the author and explaining the original paper's background as Hybrid Adapted Primary Literature (see chapter 6.1).

Schraw & Lehman (2001: 35) present another reason for presenting the author to the students, namely an increase of 'vividness'. Vividness describes passages that are suspenseful or engaging in any kind, and belongs to research on situational interest, i.e. short-living environmentally induced interest originated through the reading of a text (Schraw & Lehman 2001: 23). Giving the author a platform outside of the main text is a compromise that emphasizes the communicative purpose of the text and increases interest, which also leads to better comprehension, according to Ardasheva et al (2018). Additionally, if known, one can include the reason for the production of the research, and its reception. Concerning the reception of research articles, one can easily find every citation of the article on the journals' homepages. Yarden et al (2015: 20) describe the inclusion of controversial opinions as a delimitative factor towards popular science texts in newspapers, in which counterarguments are often omitted.

The reason for discussing the question of voice here, is that "the identification of different voices and their sources reveals relations (such as refusal or acceptance) between the authors and those *Others* they are integrating in their own message, and that this interaction is essential to the interpretation of the text as a whole" (Fløttum 2012: 228). When adapting primary literature, one has to keep these integral features of scientific writing in mind, and to attempt not to change the voice, for example by cutting out important attributional or averral signs of the author's position. However, following the research on HAPL (Shanahan et al 2009,

Shanahan 2012) one can strengthen the voice, by explicitly stating the authors background outside the main text in a narrative text resembling an ‘About the author’ section. Non-interactiveness, i.e. not addressing the reader, is also a feature universal to all academic research articles. As part of a larger discourse community, research articles are always addressed to somebody with the aim to persuade this audience (Fløttum 2012: 221), however explicit ‘addressivity’ in form of reader address is not common. Again, the adaptation step of ‘highlighting scientific communication’ can circumvent this tension between authenticity and adaptation through incorporating the community, the article is mainly addressed to, in the narrative part of the HAPL text.

The need for scientific communication often originates from controversies between the aforementioned parties, the author(s) and the primarily addressed researchers who have a different opinion. As controversies are usually omitted in the most commonly read science texts, the journalistic reported versions, it is important to highlight the argumentative nature of PSL and consequently APL. When adapting a PSL article towards an HAPL article, one can use the narrative text to present the controversy which constitutes the main reason for writing the original paper.

After making the communicative purpose and the interlocutors explicit through adding a narrative text, only the last step of adapting PSL is missing. This step, however, cannot be placed in the sequential order of the last six steps, since it has to be done continuously throughout the previous steps.

7.8. Recurring evaluation

The strategy of recurring evaluation has been suggested by the students whose adaptation process Khristawan & Widiati (2013) observed. They claimed that they had to evaluate their modification measures on several occasions. Questioning their own modifications often happened during the adaptation process. After one clause was paraphrased, it was evaluated automatically right after the adaptation happened. Grammar accuracy and semantic equality were mostly checked after finishing the modification of a whole sentence and again as a last step after finishing a full paragraph, which was their goal (Khristawan & Widiati 2013: 149). While evaluations throughout the process are important, the last evaluation of the HAPL text before using it in class, is still the most crucial one, and should be done thoroughly. Lebrun (2011: 54) suggests asking oneself these questions when having finished a paper:

Read your paper. [...] Is it motivating? Have you identified a ground zero that is reasonable to expect from your reader? [...] Have you identified the intermediate discoveries that removed the sandbags of your ignorance and elevated your knowledge above that of the reader?

III. Empirical Study

Having outlined the theoretical background of input modification and Adapted Primary Literature, as well as the reading process and the concept of Content and Language Integrated Learning, the following chapters present the application of the theory on an PSL article and its integration in an empirical study. The study was conducted in an Austrian upper secondary school in order to ascertain differences regarding the comprehension of the original PSL and the HAPL version that was adapted according to the theories presented in this diploma thesis. First, the research questions are defined and the details, such as a description of the school and the participants, are described. Following this, the application of the adaptation steps is exemplified. After presenting supporting literature for the design of the reading comprehension test and the questionnaire, the data collected through the study is presented and discussed.

8. Basic description of the study

The aim of this study is to ascertain whether HAPL can help students comprehend a scientific article better, and how it is connected with students' interest and prior knowledge. The main research questions can be phrased like this:

- To what extent can the use of HAPL in the CLIL biology classroom improve reading comprehension of a scientific article?
- How is prior knowledge and interest connected with the reading comprehension of an HAPL text?
- How is the experience of reading PSL texts for the 'Vorwissenschaftliche Arbeit' (VWA) linked with the comprehension of scientific texts?

The main hypothesis of this study is that the teacher can foster students' comprehension of Primary Scientific Literature by changing it into a Hybrid Adapted Primary Literature. Additionally, student characteristics and attitudes are cross-referenced with their comprehension scores. Next, the school, participants and other details of the empirical study are described.

The 'Bundesrealgymnasium Wien 14' is located at the Linzerstraße 146, 1140 Vienna. The school, consisting of 35 classes for eleven to eighteen-year-old students, is one of the cooperation partners of the University of Vienna. This openness towards research led to the selection of the school for the present study. The bilingual branch of the school is described as a dual language program on the website of the school (http://www.brg14.at/?page_id=4238). However, as mentioned in the chapter on CLIL, this program resembles the concept of English across the curriculum more, since not all subjects are taught bilingually, and the main language in the school remains German, while the students in the program are certainly more often exposed to their first foreign language, i.e. English (see chapter 1 on CLIL). Both classes were part of the 'Vienna Bilingual Schooling' program which states that CLIL is the main teaching approach (http://www.brg14.at/?page_id=4205).

Regarding the basic background information of the students, the questionnaires included questions to describe the participants adequately. On the day of the study, class I consisted of 13 students, and in class II 16 people were present. In total, twelve 17-year-olds and seventeen 18-year-olds took part in the study. When it comes to the gender of the students, fifteen were male and fourteen identified as female. Concerning their first language, twenty-three participants stated only German as their mother-tongue, and only one did not state German, but Serbian as his first language. The rest of the students stated two languages with German being one of them and one other language, each stated by only one student. The languages of these bilingual were: Korean, Croatian, Persian, Bulgarian, and Portuguese. To graduate from secondary school in Austria, each student has to write an academic text called 'Vorwissenschaftliche Arbeit', which is also the case for the participants of this study. The language and topics of their VWAs will be discussed in a later chapter. These facts stated by the students can help characterize the group of participants. To get a general impression of the circumstances of the study, and how it was administrated, it is described in the next section.

Before the administration of the empirical study, the permission of the head teacher was obtained and the biology teacher of the two classes in the dual language program signed a permission letter as well. 6 weeks before the study, permission letters for students who were already 18 (17 students) and permission letters for the parents of the 17 year-olds (12 students) were sent to the class teacher and handed to the students. All these documents can be found in the appendix. The study was administered by the researcher in the presence of the class teacher, which has the benefit that the researcher can introduce the study and can ensure that everybody participates simultaneously (Cohen et al 2011: 404). The data was gathered on the 30th January

2019. Class I participated in the study during the first lesson, instead of their biology class. The class II took part in the study during the 5th lesson of the day, instead of their geography lesson. Both classes would participate in a sports tournament the next day, which could have influenced their motivation to spend 50 minutes on the reading of a scientific article.

Having described the setting of the study, one has to acknowledge the limitations of the research as well. One limiting factor was the rather low number of students. Due to the limited scope of the project only one single school was chosen to gather the data quickly and efficiently. The study should be seen as a pilot study for future researchers and teachers as basis for developing Adapted Primary Literature and assessing its effectiveness. When it comes to student-related reliability, factors such as the mood of the students during the study, which was undertaken in the last week of the first semester, and their lack of motivation to read such a long text at the end of the semester might have influenced the results. For example, one student mentioned in the questionnaire that he was overfatigued, and therefore he could not concentrate on the reading task. Another student criticized that, for participating in the study voluntarily, the text was too long, which could have lowered her motivation to read it. Such factors might have influenced the results, however, they are inevitable in a school setting. Next, the creation process of the texts used in the study will be described.

9. Study instruments

9.1. Creating a text through theories of HAPL and linguistic modification

After describing the theories of input modification and HAPL and the adaptation steps deduced from these theories, these steps have been applied on a PSL text, in order to use it in an empirical study. Before the adaptation process an article had to be chosen.

Concerning the selection of an article, the criteria list from chapter 7.1, was applied and each criterion eliminated roughly half of the possible research articles. Starting with 50 possible articles the twelve non-sequential steps were executed until there was only one left: *Spread of volunteer and feral maize plants in Central Europe: recent data from Austria* by Kathrin Pascher (2016). While not all criteria were applicable in this specific context, they are still mentioned for the sake of completeness.

1st criterion: “Complements relevant curriculum content” (Yarden et al 2015: 84).

The research process starts with a look at the curriculum to see which topics are relevant for the 8th grade of an Austrian grammar school. The topics of modern healthcare research, cytology,

genetics, evolution and genetical engineering were then compared with the key research areas of the faculty of life sciences: Climate Change Biology; Computational Life Sciences; Cognition, Neuroscience and Behaviour; Drug Discovery from Nature; Ecology and Biodiversity of Tropical Forests; Evolution of Organismal Complexity; Microbial Ecology and Ecosystems; Nutrition-associated Molecular Mechanisms of Ageing; Patterns and Processes in Plant Evolution and Ecology; Symbioses. On the website of the faculty of life sciences (<https://lifesciences.univie.ac.at/>), these categories are divided into the single departments that work on the specific research area, and each department usually has a homepage where the university presents recent publications. The most recent titles of nearly all departments were then scanned for overlaps with the curriculum.

The biology curriculum for upper secondary (Lehrplan 2004: 1) mentions the inclusion of professional and specialized literature in the section about language and communication competences, as discussed in the literature review. Concerning the content of the paper chosen for this diploma project, there are two instances that led to the choice of the article by Pascher (2016). Under the broad heading of “Weltverständnis und Naturerkenntnis [understanding the world and nature]” (Lehrplan 2004: 4) and the sub-heading of genetics, the ministry prescribes that teachers help the students to acquire knowledge on genetical engineering and its possible effects of agriculture. Teachers should also foster a responsible attitude towards such new technologies (Lehrplan 2004: 4). A very similar content point of the curriculum is described in the section about biology and production, in which it is mentioned that students should get insights into research and applications of genetics in context of plant-breeding with examples from agriculture (Lehrplan 2004: 4). All these issues have connections to Pascher (2016).

2nd criterion: “Anticipates students’ motivation to and interest in reading the text” (Yarden et al 2015: 86).

In Baram-Tsabari & Yarden (2005) described earlier in this thesis, the authors chose an article which dealt with environmental pollution prominent in the news at the time. While this is one way of increasing the students’ motivation to read the text, considering the fast-paced changes in the news this selection criterion is rather time-specific. As an alternative way of increasing interest, I chose an article which presents recent research, conducted by a Viennese scientist. The study was conducted nationwide, but also leads to a larger conclusion about the whole of Central Europe. The spatial closeness of the study sites to their own home city of Vienna should increase the students’ interest. The fact that the paper was published not even more than two years ago should also show the high school students that this kind of research question could

be part of their work at the University of Vienna as well if they are interested in the field. Both the spatial and the temporal proximity help to present the study of biology at the University of Vienna, and might lead to someone choosing this path, since the subjects of the study have to choose soon if, where and what they want to study. As a teacher of a subject, trying to promote the subject and a career in the field influences your teaching, and APL offers an opportunity to present recent research conducted by young scientists at the university closest to the students. Additionally, research supports the notion that new information enhances interest in students (Yarlas & Gelman 1998 cited in Schraw & Lehman 2001: 41). Although the students are obligated to study the topic of bioengineering whether it is interesting to them or not, as the subjects of this study are already advanced students with at least six years of studying biology, one can assume that prior knowledge and interest have already developed a correlation.

When it comes to the attractiveness of the topic, beside the spatial and temporal proximity, news coverage also helps to raise the students' interest in the text, as observed by Baram-Tsabari & Yarden (2005). The topic of genetically-modified plants has been controversial in recent years with European Union (EU) -wide discussions over TTIP (Transatlantic Trade and Investment Partnership) and its implications for our agriculture, and therefore the paper selected lends itself to some interdisciplinary teaching.

3rd criterion: "Matches materials to students' prior knowledge" (Yarden et al 2015: 85).

The approximately 50 articles that passed the first selection process were skimmed again, for field-specific methods, or other knowledge demands that would hinder a successful comprehension of the text. When using the HAPL text in a longer instructional sequence the teacher can also pre-teach the experimental methodology, if part of the curriculum (Lehrplan 2004: 4). For example, if the paper includes the method of PCR, the teacher should include this technique in a pre-teaching sequence. Since the study described in this thesis does not entail a teacher-led discussion of the text or any kind of pre-teaching beside the one prescribed by the curriculum, an article with the rather simple methodology of monitoring was chosen. The same thought process underlies the paper's presentation of the results. To avoid the cognitive difficulties with visual representations of statistical data, a paper with no statistical evidence has been chosen. If the prior knowledge demands do not concern the essence of the paper, but rather unimportant details, these will be eliminated during content modification anyway. Therefore, only the lack of prior knowledge that is essential for the article should be considered here.

4th criterion: "Provides a clear and logical research approach" (Yarden et al 2015: 86).

As students are eased into academic literature through their task of writing a ‘Vorwissenschaftliche Arbeit’, enhancing their skills to develop a logical research approach is important, and can be done by exemplifying such approaches through APL. Pascher’s (2016) research approach can be described briefly and in a logical order. She observed a phenomenon (feral and volunteer maize plants in Austria) that was deemed unlikely by previous research, documented it through photographs and discussed reasons for the appearance of this new phenomenon.

5th criterion: “Adjusts to the future use of the adapted text” (Yarden et al 2015: 84).

The producer of the APL article for this diploma project had both of the earlier mentioned future uses in mind, the research purpose and the teaching purpose. Ideally this exemplification can be used for teaching purposes, however the main use is academic research, since the research includes a pilot study in a school setting. Especially when it comes to the rights of using and adapting a paper in an educational setting versus publishing it in an own academic paper, this criterion has to be considered. The research question influenced the selection process as well as the curriculum of the participating students, which will be the focus of the next criterion.

6th criterion: “Supplements the instructional sequence” (Yarden et al 2015: 85)

As genetics and the impacts of genetical engineering on agriculture are core topics in the 8th grade curriculum (Lehrplan 2004: 4), the text adapted in this diploma thesis supplements the instructional sequence, which happened for the most part before the study, according to the teacher.

7th criterion: “Establishes credibility of the sources” (Yarden et al 2015: 85).

While the most credible journals, like *Science* or *Nature* might be good sources of PSL articles, they rarely publish papers by Austrian scientists who present Austrian data. During the research and selection process for this study, one important factor was the accessibility of the article. One has to have not only the rights for reading the article, but also to adapt it, always having in mind to keep the results uncompromised, naturally. Therefore, opensource journals, which are sometimes less reviewed than the famous journals *Science* or *Nature*, lend themselves more for creating HAPL, even though they might be less credible. Concerning the adulteration of content and the legal issues connected with Pascher (2016), one has to look at the policy of the publisher of the journal *Environmental Sciences Europe*. According to SpringerOpen, the publisher of this study’s paper, and all papers of this open-access journal are allowed to be copied and altered “provided that no substantive errors are introduced in the process” (<https://www.springeropen.com/about/open-access>).

8th criterion: “Provides visualization to complement the results” (Yarden et al 2015: 86).

Visualizations are important in illustrating the results, in the case of Pascher (2016), her observations and their locations. Since the students read the text without any help from their teacher or anyone else and the focus of this study lies on reading comprehension, the paper chosen includes no graphs, only a map and photographs. When it comes to photographic images, Norris et al (2012) mention that they can be used “to inspire students about scientific discoveries and motivate them in their course work”.

9th criterion: “Provides a variety of research subjects, experimental organisms, and research approaches” (Yarden et al 2015: 86).

Since this criterion is intended for the teaching of an APL based curriculum, it does not concern this study, yet it is still mentioned to give a complete picture of Yarden et al’s (2015) own selection process.

10th criterion: The article does not demand too much linguistic background knowledge

While linguistic modification can reduce the language demand, some papers, for example in the field of genetics, incorporate complex names and concepts unknown to students to such a great amount that a linguistic modification would not be possible anymore. In Pascher (2016) this is not the case, therefore a glossary and the other modification steps can adapt the text without the need for a complete rewriting.

11th criterion: The main information is presented in words

While photographs and a map support the results, Pascher (2016) also describes her findings in words.

12th criterion: Length

Pascher (2016) with its 8 pages lends itself for an adaptation, since students with English as a second language do have slower reading speed, and this study was held during a 50 minutes lesson in which the students had to finish reading the paper and filling out reading comprehension questions and questionnaires.

Concerning the comprehension of the article, during the selection process the gist of the article has already been comprehended. However, more detailed comprehension is necessary before starting the modification process. The comprehension started with global comprehension, which focuses on the connection of the author’s ideas (Khalifa & Weir 2009: 45). After that,

the adaptor read T-unit by T-unit to comprehend the specific information of each unit. This is needed for the next step, content modification.

The content modification applied on Pascher (2016) mostly considered less important background information, and not relevant results. The latter can be exemplified through the passage “As can be seen in Fig. 1i–k, the plants have grown on a rather open site together with the black locust (*Robinia pseudoacacia*) which is known as an especially aggressive invasive species” which has been deleted during content modification. Concerning irrelevant background information, the sentences “Maize, domesticated by native Indians of Mexico and northern Central America already about 5500 years ago, has been introduced to Europe in 1525 owing to the discovery of America by Columbus. Since then, a large number of local varieties have been developed all over Europe.” can be used as examples for content deletion. Despite not using politically correct language, the history of maize is not really relevant for comprehending the article. An example for content elaboration is the sentence “This means that GM maize can spread, and nobody knows the consequences this could have” (Pascher adapted 2019: 3) which is a redundant passage, repeating the meaning of the previous sentence. This should help comprehension and has been done several times.

When it comes to structural standardization, to present the standard IMRD-structure to the students, Pascher (2016) had to be adapted. Some of the sections were named differently, e.g. “background” (Pascher 2016: 1) instead of ‘introduction’, and the results and discussion sections were not clearly distinguishable but were a mixture of both. Although Marwan (2017: 110) mentions that “discussion sometimes can be put together with the results, making its results and discussion” the standard structure of PSL articles consists of Introduction-Methods-Results-Discussion and possibly a conclusion, or other additions (van Enk & Power 2017: 4).

The title was left unadapted, since, in general, students prefer titles with colons, according to Lewison & Hartley (2005: 563). The abstract was rewritten completely, however, it still has strong parallels to the original one. Concerning the adaptation of the introduction, the research article at hand clearly presented the motive and objective of the research. The only structural changes were to include some of the existing research from the discussion section already in the introduction. The method section was only simplified to be less detailed, structural standardization was not necessary. The results section of Pascher (2016) was intertwined with the discussion, and also some parts that should have been already mentioned in the introduction. For example, the passage “Left overs reach the manure and in this way are dispersed into the environment during fertilisation. Feeding of game (e.g. wild boars) by hunters or fowl kept in

an animal husbandry could be another source for the entry of single-maize kernels into semi-natural and natural habitats [...]” is background knowledge which presents the work already done in the field, and which is important to understand the problem. In the discussion section, such facts are restated and used to support the author’s argument. Since the results are presented in photographs and text, one does not need to adapt this section extensively, despite explicitly stating that these elements are the results, through the heading ‘results’. In Pascher (2016), the discussion and conclusion are separated. The discussion draws on different previous research again, and the conclusion also fulfills its function of presenting the most significant message and implications for the future. Beside moving some of the background knowledge on game feeding into the introduction, no bigger adaptations were necessary concerning the structure of those sections.

Concerning other additions, the two biggest addendums to the original PSL article are the background box at the beginning and the glossary right after this narrative text. The latter will be discussed in the next chapter on lexical modification. The source for the information in the background box were reviews of the article, for example Naegeli et al (2017) and Naegeli et al (2018), as well as an interview with Kathrin Pascher herself. The narrative text will be discussed further in chapter 7.7 on highlighting communication

When it comes to lexical modification, this step was one of the most time-consuming phases of the adaptation. As mentioned in the theoretical guideline, the keywords identified can be put in a glossary box inserted before the main text. The first examples already appear in the title of Pascher (2016): “volunteer” and “feral”. The adaptor had to add explanations for words like volunteer because of their polysemous nature. In the article simplified for this study, the terms in the glossary include academic or scientific jargon which are key terms for understanding the article. The paraphrases for both in-text paraphrases and the glossary explanations were mostly drawn from three dictionaries: *Dictionary of Agriculture* (Bateman et al 2006), *A Dictionary of Genetics* (King et al 2006) and *A Dictionary of Biology* (Hine 2015). Some scientific terms, such as “hypotheses” or “systematisation” have been kept, as the roughly 2 % of unknown jargon in a text, suggested by Wan-a-rom (2008: 44). This is done to foster vocabulary learning and the understanding of important concepts of the academic world. The academic terms were identified through academic word lists such as the Academic Word List by the Oxford English Dictionary based on work done at the Victoria University (<https://www.oxfordlearnersdictionaries.com/wordlist/english/academic/>).

Simplification can be exemplified through the exchange of the word “prolonged” (Pascher 2016: 2) with “lengthened”. The latter term does not belong to the scientific terms listed in the Dictionary of Agriculture (Bateman et al 2006: 198) while the original term is described there. The importance of the context for meaning (see chapter 7.5) can be illustrated with a term often used in Pascher (2016: 2): “hybridization”. The Oxford English Dictionary Online offers five different definitions of the term which depend on the specific sub-field its used in. Not to mention that all of the five different sub-fields are part of the ‘Biologie und Umweltkunde’ curriculum.

Regarding syntactic simplification, the reduction of the five features that increase the cognitive load of T-units was only executed in a few cases. This was due to the complexity of the topic and the typicality of complex sentences of the academic genre of PSL, which are features the students need to be exposed to. For example, through deleting the phrase “In case of cultivation of GM maize” (Pascher 2016: 1) the adaptor decreased the degree of embeddedness. Since this feature is measured by the number of words within the T-unit that appear before the verb, it decreased from 11 to 4, and hence should be more comprehensible.

In contrast to that, grammatical metaphors were often modified into congruent forms. For example, “volunteerism and ferality of maize” was transformed into “maize becoming feral or volunteer”. This is just one of many reductions of grammatical metaphors.

Concerning the step of highlighting the communicative aspect of scientific research articles, the goal is to emphasize the presence of the interlocutors, i.e. the author(s) and the intended audience. However, since the author usually tries to portray his/her research as objective and addressivity is also very uncommon in the writing of research articles (see chapter 5), one has to do this step outside of the main text. Concerning the use of pronouns, Pascher (2016) is in line with the findings of Martinez (2005), who shows that native English scholars use twice as many first person pronouns than their non-native colleagues. This is also the case in this paper (Pascher 2016), with zero instances of first person pronouns.

When it comes to controversies in academia, the article chosen for this study is highly representative of how scientific communication works. The research executed by the European Food Safety Authority (EFSA) is refuted by Pascher’s (2016) findings. Furthermore, if one analyzes the reception and citations of the article, for example in the EFSA journal, one can see that several authors (Naegeli et al 2017, Devos et al 2018, Naegeli et al 2018) criticize and downplay Pascher’s (2016) findings, most times with the exact same phrasing:

Field observations indicate that maize grains may survive and overwinter in some EU regions, resulting in volunteers in subsequent crops (e.g. Gruber et al., 2008; Palaudemas et al., 2009; Pascher, 2016). However, maize volunteers have been shown to grow weakly and flower asynchronously with the maize crop (Palaudemas et al., 2009). Thus, the establishment and survival of feral and volunteer maize in the EU is currently limited and transient.

Additionally, Pascher (2016: 7) has to state explicitly in an own section that “[t]he author declares that she has no competing interests” and list all the funding she has received:

Writing of the paper was funded by the Austrian Federal Ministry of Health and Women’s Affairs. Field observations were made during the projects BINATS, FEAR and the project “Risk of seed spillage of imported oilseed rape along transport routes—Assessment of potential medium-term to long-term effects of an accidental entry of viable seeds in Austria” which were financed by the Austrian Federal Ministries of Health and Women’s Affairs and of Agriculture, Forestry, Environment and Water Management.

The background box tries to summarize the controversy with the EFSA and present the author so that the text seems more vivid, and therefore, is more interesting.

The recurring evaluation of the adaptor was complemented by a review by the original author, to avoid any content, or linguistic modifications that alter the original meanings and intentions of the author. Furthermore, beside continuous self-evaluation, checking-levels in our adaptation were mostly at the T-unit level, sentence level and paragraph level. Especially between the steps of lexical elaboration and syntactic simplification, one has to make sure one does not delete the previously introduced elaborations, to reduce syntactic complexity.

9.2. Design of the reading comprehension test

Two important concepts of testing are reliability and validity. For further discussion one needs to define these terms first:

Reliability refers to the consistency of a test. It must be able to generate, for the same person, comparable scores from one day to another, in different situations, or following a second test comparing equivalent items. [...] Validity refers to a test’s ability to measure the construct that it is designed to measure (Roy-Charland et al 2017: 1432).

The test items are all selected-response items. When it comes to receptive skills, selected-response items, which offer a set of alternatives to choose from, are the best option. This is the case because students do not need to produce language on their own which can be a limitation factor (Brown & Hudson 2002: 59). An additional advantage of selected response formats is the increase of test reliability through better internal consistency and marker reliability (Khalifa & Weir 2009: 83). Furthermore, this format is useful for “large scale assessments for testing

detailed understanding of the text” (Khalifa & Weir 2009: 83) which is the goal of our reading comprehension test. As exemplified by Cambridge examinations and classroom practices, students should read the text first and then do the comprehension task (Khalifa & Weir 2009: 84).

The use of multiple choice items can be found in many fields beside language testing. Gronlund (2003) concisely describes the structure of multiple choice items:

Multiple choice items consist of two parts: a stem, which presents a problem situation in the form of a question or an incomplete statement, and a set of several, usually three, four or five alternative answers, options or choices, which provide possible solutions to the problem (Gronlund 2003: 60, referred to in Hinterlehner 2010: 20).

Concerning the number of alternatives, Gronlund (2003: 60) mentions that normally there are three to five answers, and van Berklom (2009: 102) also states that students can usually tackle questions with four or more answers. Following the examples of Oh (2001) and Li et al (2005), our multiple-choice items offer four alternatives.

Van Blerkom (2009: 92-98) lists and explains twelve “attributes desired in multiple choice items”. Some seem rather basic, for example: “1. [t]he item should measure the skill or knowledge that it was designed to measure” (van Blerkom 2009: 92), i.e. be valid, and “10. [t]he grammar of each option agrees with the stem” (van Blerkom 2009: 97). While number 1 seems clear, researchers found that several prominent tests, such as the Scholastic Achievement Test, or the Stanford Achievement Test (Roy-Charland et al 2017: 1432) have this validity problem in their reading comprehension tests (Roy-Charland et al 2017: 1432). In more specific terms, these tests include items that are passage-independent. Passage independency describes the possibility of answering a multiple-choice question correctly without having read the text (Roy-Charland et al 2017: 1432). Desired attribute number 10 refers to mistakes which give away that an answer can be eliminated, because the alternative does not agree grammatically with the stem. Van Berklom (2009: 96) exemplifies these mistakes with the a/an disagreement between stem and distractor.

These attributes desired for multiple-choice items have been incorporated in the test design for this study and will be described in detail in the following paragraphs. The attribute mentioned secondly “[t]he reading level of the item is appropriate for the students” (van Blerkom 2009: 92) is the logical consequence of the fact that one item should not assess more than one characteristic. If the reading level is too high, the item measures reading ability and knowledge,

therefore, one should stick to simple sentences, if possible (van Blerkom 2009: 92). Readability is also of importance for the next attribute: “3. The stem presents a clear and complete question” (van Blerkom 2009: 92). An unambiguous stem should help the students being able to answer the question even without having to read the answers” (van Blerkom 2009: 92).

The next attribute is especially important when testing knowledge of PSL articles: “4. The correct alternative is one with which experts in the field would agree” (van Blerkom 2009: 93). This feature refers to the tension of simplifying complex matters for pedagogical purposes to the point where the modification is not correct anymore. In our case the correctness of the question is not only examined by the author of the test, but also by the author of the original text (Pascher 2016). The fifth attribute addresses the difficulty of creating “distractors [that] are plausible but clearly wrong” (van Blerkom 2009: 94). If distractors are not plausible, the reliability of the test results suffers, but if they are partly correct or ambiguously formulated, students can be easily confused (van Blerkom 2009: 94).

Some straightforward suggestions are that “[e]ach of the alternatives should have similar content” (van Blerkom 2009: 94), which tells the reader not to include an odd concept which is highly different from the others, and “[w]henever reasonable, the alternatives should be listed in a logical order” (van Blerkom 2009: 97), which only addresses questions with a numerical response.

When it comes to conciseness, one should avoid repetitive words in the answers by moving them into the stem, while at the same time keeping the stem “as concise as possible” (van Blerkom 2009: 95) to increase readability. For the same reason one should “[a]void using modifying words in the stem of the question that significantly alter the meaning of the question or statement” (van Blerkom 2009: 95), such as ‘not’, ‘except’ or ‘least’. If the test designer still has to use these modifiers, he/she should highlight them for more clarity (van Blerkom 2009: 95). The last attribute desired in multiple-choice items is that “[w]henever possible, [one should] avoid options such as ‘all of the above’ and ‘none of the above’” (van Blerkom 2009: 97), since these answers decrease the reliability of the test and confuse students (van Blerkom 2009: 97).

Concerning the validity of a reading comprehension task, the aspect of text length has to be considered as well. While the length is no indicator for text difficulty (Rahimi 2011: 15), keeping the length of the article of this study increases the validity of the reading

comprehension task, since Chujo & Utyiama (2005) pointed out that text length is a variable in the intelligibility of reading materials.

Using Li et al (2005) as an example, all participants answered the same amount of multiple-choice questions, without regard to the type of text they had to read. The test consisted of 12 items. Cohen et al (2011: 384) suggests clarifying how many responses should be picked, which was done with the phrase: “Circle the right response:”. Following Oh (2001) & Li et al (2005), “to explore the differential effect of input modification types on different kinds of comprehension processes, the test included three types of comprehension items, assessing (a) general comprehension, (b) specific comprehension, and (c) inferential comprehension” (Oh 2001: 77).

Questions (1), (4), (8) & (12) (see Appendix C) test *general comprehension* through questions of judging the author’s attitude, and of finding the main topic of a passage (Oh 2001: 78). In contrast to these stand questions (2), (5), (6) & (10), which are *specific comprehension* tasks. These questions demand paying close attention to explicitly stated facts so that one can answer, for example true or false questions (Oh 2001: 78). The last category of reading comprehension items is *inferential questions*. The four questions (3), (7), (9) & (11) involve making implications, such as the topic of the following passage, etc. (Oh 2001: 78). Inferential comprehension demands that students predict information beyond the text, which includes critical thinking and complex processing skills (Li et al 2005: 51). This type of predictive inferencing is often also called ‘elaborative’ inferencing. Checking for elaborative inferencing, questions if students have comprehended the content of the text and have learned the necessary background knowledge to predict further information.

Some studies that support the inclusion of inferential questions in the reading comprehension task for a PSL and HAPL text are mentioned in this paragraph. For example, Bowyer-Crane & Snowling’s (2005) study on childrens’ inference generation and reading comprehension showed that elaborative inferencing is directly correlated with the subjects’ reading skill levels (197). The inferential questions were designed after the examples of Cromley et al (2010: 699). Their paper also emphasizes the importance of inferencing on reading scientific texts, since “increasing the number and quality of inferences drawn while reading science text increases comprehension” (Cromley et al 2010: 688), and especially elaborative inferencing benefits comprehension (Cromley et al 2010: 688). Singer & O’Connell (2003: 608) reinforces that the genre of academic expository texts makes inferencing harder due to “the complex structures,

distinct reader goals, and unfamiliar information”. Nonetheless scientific expository texts, in general show only a small amount of predictive inferences within the text, in contrast to narratives (Otero et al 2002: 204).

Whilst there are different reading strategies for the different types of comprehension tested in this study, they are not completely exclusive, e.g. “teaching specific reading comprehension strategies to students also increases correct inferences” (Cromley et al 2010: 688). Furthermore, McMaster et al (2015: 30) discovered that students who outperformed others in making elaborative inferences struggled with general comprehension questions and vice versa. These findings and the fact that Li et al’s (2005) study showed improvement through simplification in specific, general and inferential comprehension led to the decision to base the reading comprehension task on their paper.

Concerning the timing of the reading comprehension tasks, McMaster (2015) offers some suggestions. Reading comprehension as a process leads to a coherent representation of the text, according to the cognitive model approach (McMaster 2015: 29). The question of when to test this construct is of importance. On the one hand, one can administer the test during reading (i.e. online), or following the reading exercise (i.e. offline) (McMaster 2015: 29). For older students, as is the case in our study, McMaster et al (2015:29) suggest executing the reading comprehension task after the subjects have read the text, so that the test does not interfere with the cognitive processes during reading. They also left the texts with the students when starting the comprehension task and prompted the students to use the text to answer the questions (McMaster 2015: 32). This study follows this example of testing reading offline.

9.3. Design of the student questionnaire

The questionnaire students filled out after the reading comprehension tasks consisted of questions drawn from other diploma theses in the field of CLIL (Bürger 2017, Klampfl 2010) and research in the field of the questionnaire as a research method (Dörnyei & Taguchi 2003, Cohen et al 2011) and literature on ‘Adapted Primary Literature’ (Norris et al 2011). Following the example of Bürger (2017) and Klampfl (2010), the questions were asked in German to avoid any language difficulties. The structure follows Dörnyei & Taguchi (2003), starting with a title and an instruction box. The general and specific instructions include the topic of the study, the researcher’s institution, “emphasizing that there are no right or wrong answers; requesting honest answers” (Dörnyei & Taguchi 2003: 19), a promise of confidentiality, and specific instructions consisted mainly of how to answer the questions correctly (Dörnyei & Taguchi

2003: 19). When it comes to the layout, the only aspects applied are Dörnyei & Taguchi's (2003: 14) suggestions to have a "well-designed, orderly layout that utilizes various typefaces".

Concerning the length of the questionnaire, it was very limited by time issues, since the reading comprehension tasks and questionnaires had to be filled in in only 50 minutes, and one should design the questionnaire with the slowest reader of the class in mind (Dörnyei & Taguchi 2003: 13). Cohen et al (2011: 385) suggests not to use more than five items to choose from, to not overwhelm students, therefore, five categories are also in the questionnaire of this study. The names of the categories were drawn from Cohen et al (2011: 387) and translated. Questions were also designed in line with the chapter on pitfalls mentioned in Cohen et al (2011: 396-397). The dangers avoided are: leading questions; ambiguous, sophisticated language; complex questions; irritating instructions; too many open-ended questions; extremes in rating scales; biasing by association (Do you agree with ...?).

The sequence of the questions also follows Cohen et al's (2011: 398) suggestions: Starting with factual questions, which are used to cover relevant background information relevant to the interpretation (sex, mother tongue, ...) (Dörnyei & Taguchi 2003: 5). This first part is superseded by closed questions, behavioral questions as well as attitudinal questions. Behavioral questions concern themselves, for example with learning history (Dörnyei & Taguchi 2003: 5), such as "Hast du für deine VWA englischsprachige wissenschaftliche Texte gelesen, wenn ja wie viele?" (see Appendix C). Attitudinal questions include questions about "attitudes, opinions, beliefs, interests and values" (Dörnyei & Taguchi 2003: 5), so in general they "find out what people think" (Dörnyei & Taguchi 2003: 5). The questionnaire of this study includes an attitudinal question as well: "Hat dich der Artikel motiviert mehr über das Thema oder die Biologie als Wissenschaft zu lesen?" The attitudinal questions were selected from Norris et al (2011: 647) and adapted to the context. For example: "I would like to know more about the article's subject" Norris et al (2011: 647) was changed and translated to "Hat dich der Artikel motiviert mehr über das Thema oder die Biologie als Wissenschaft zu lernen?" (see Appendix B). Cohen et al (2011: 398) mentions that the last part of a questionnaire should consist of open-ended questions, which is limited to one such question at the end of the questionnaire.

Additionally, one should start with objective questions to subjective ones and from general to specific questions (Cohen et al 2011: 398), which has also been applied to the questionnaire of this study. Since the grade of last year or the admittance that one has not understood a text fully can be sensitive topics, they are dealt with at the end of the questionnaire. To diffuse these

sensitive items the questionnaires are executed anonymously, as suggested by Dörnyei & Taguchi (2005: 17). The question “Wie viel Prozent des gerade gelesenen Textes glaubst du hast du verstanden:” (see Appendix B) was translated from Oh (2001: 78), to assess the perceived comprehension. It was incorporated in the questionnaire, to emphasize that this question is not marked, and should just be answered honestly, as mentioned in the instruction box. The last question is an open-ended, personal response question to identify the students’ perceptions on difficult elements. Since the language of the questionnaire is German, the negative impact of that language production can have through language difficulties is kept to a minimum. The answers of the open-ended question are analyzed qualitatively (see chapter 10.3)

When it comes to the timing of the questionnaire, it was handed out together with the reading comprehension tasks and the texts themselves. Yet, the three parts were ordered first text, then comprehension tasks and lastly questionnaires so that students read the sheets in this sequence.

10. Data analysis and discussion

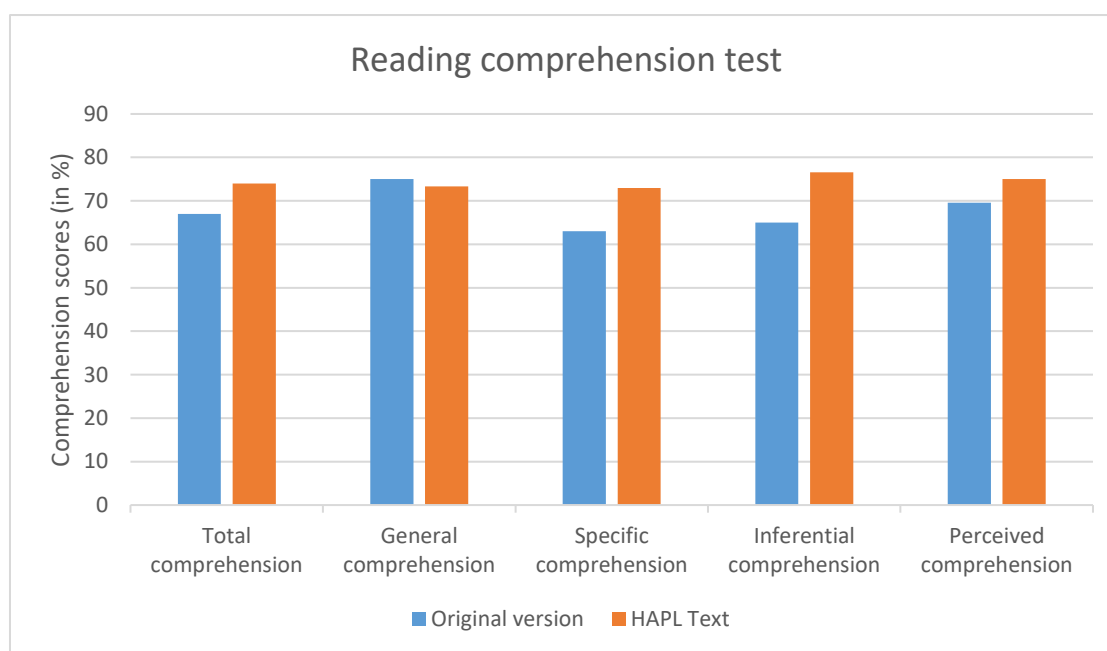
The data collected through the comprehension test and the questionnaires is presented through graphs. Starting with the display of the different comprehension types, the total comprehension is correlated with student characteristics gathered through questionnaires.

10.1. Assessment of the reading comprehension test

The reading comprehension tests were answered before the questionnaires. Each of 12 items had four possible answers. If no answer was marked, or one of the three distractors, i.e. wrong answers, were marked, the answer was considered to be incorrect. Before discussing the three different categories, all the comprehension results are presented compactly in graph 1.

To discover if the differences between the means of the two groups are statistically significant t-tests have been executed and the results will be presented in the discussion of the single comprehension types. The variant of t-test used was the t-test for independent samples, since the “two groups are unrelated to each other” (Cohen et al 2011: 543). The probability value (p-value) shows if the difference is statistically significant, or it is only a side-effect of a larger variance. The p-value that must not be exceeded for the result to be significant is 0.05, i.e. $p < 0.05$ = significant difference between mean values versus $p > 0.05$ = no significant difference between mean values (Cohen et al 2011: 544).

Graph 1: Results of the reading comprehension test for both groups (in percent)



All discussions of the different comprehension types include a graph comparing the mean values of the two groups, one graph showing the frequency of the number of correct answers, and one graph that includes boxplots, which show the variance of the two groups.

The total comprehension of the students who read the original PSL article was at 68.9% (see graph 2). This means that the participants, on average, answered more than 2/3 of the comprehension questions correctly. This result is exceeded by the students who read the HAPL text. The mean of total comprehension scores for this group is nearly 75%. While the difference in mean values would suggest an increase in reading comprehension due to the adaptation, the t-test shows that this difference is not statistically significant ($p = 0,13$). One can answer the research question: “To what extent can the use of HAPL in the CLIL biology classroom improve reading comprehension of a scientific article?” with “The extent to which the HAPL text improved reading comprehension in comparison with the original version was not significant”.

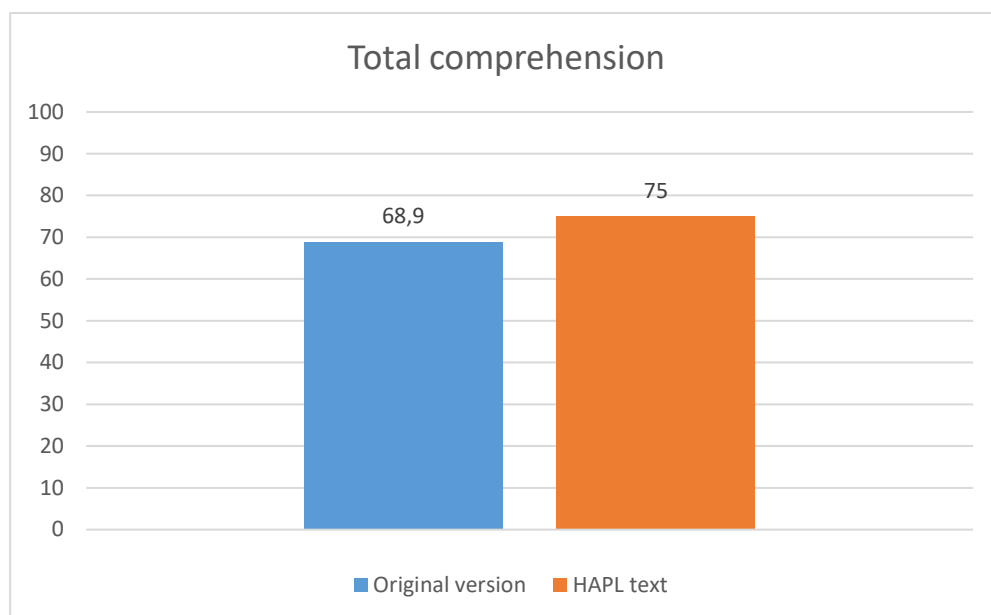
Graph 3 illustrates the frequency of students’ total comprehension scores. One can see that only the HAPL group includes students that answered eleven out of twelve questions correctly. The group of readers of the original version, however, show a large number of participants that answered nine questions correctly ($n = 7$). Noticeable as well are the two individuals that only scored four points on the reading comprehension test.

To illustrate why the difference in mean value is not statistically significant, graph 4 shows the similar variances of the total comprehension scores. Graph 4 also illustrates that the variance of the HAPL text was smaller than for the original text. This can be interpreted as the HAPL text being more successful in not leaving individual students out. Therefore, even if the difference is statistically not significant, the narrower range of results for HAPL could be an indication that it might foster reading comprehension better. For more valid results another, larger study would need to be undertaken.

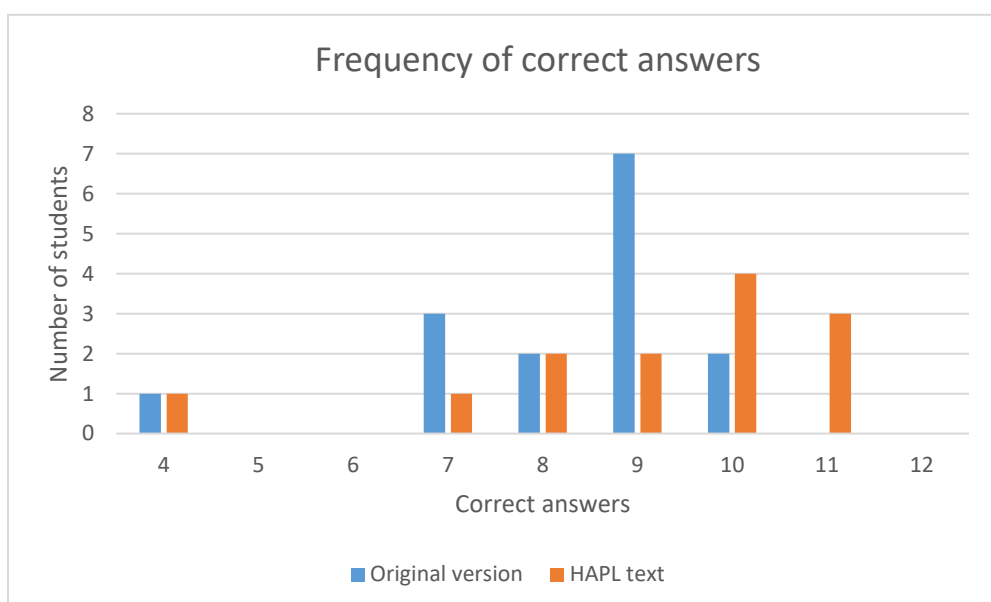
While Rahimi's (2011), Oh's (2001), and Li et al's (2005) studies showed an improvement in reading comprehension for both modifications, simplification and elaboration, this cannot be observed to a significant amount in the present study. Therefore, one can conclude that the results for total comprehension, while showing a small increase, cannot show such a significant difference as the previous literature on the subject.

When it comes to the means of general comprehension scores, the participants who read the original version show a slightly higher turnout than those who read the HAPL text, as observable in graph 5. While there is a small difference, the hypothesis that the HAPL readers would have higher comprehension scores could not be confirmed, due to the t-test which shows that this difference is statistically not significant ($p = 0.49$). The general comprehension scores of the readers of the original version have the mean value of $M = 2.933$ and the standard deviation $SD = 0.703$. The readers of the HAPL text showed a mean value of $M = 2.928$ and the standard deviation $SD = 0.997$. In graph 6 one can see that the original version showed fewer instances of students with all four questions correctly answered. Additionally, the graph shows that the HAPL readers included one participant with only one correct answer. While the difference in mean value is statistically not significant, the frequency of students with all correct general comprehension questions is higher in the HAPL group ($n=5$) than the frequency of the original version readers ($n=3$) (see graph 3 and 4). This could be interpreted as a favoring factor for using HAPL texts. The general comprehension items are questions number 1,4,8, and 12 (see appendix). Since the literature on this type of comprehension (Oh 2001, Li et al 2005) differs, the only aspect of the results of the present study that goes in line with past findings is that modification does not have to improve the general comprehension scores.

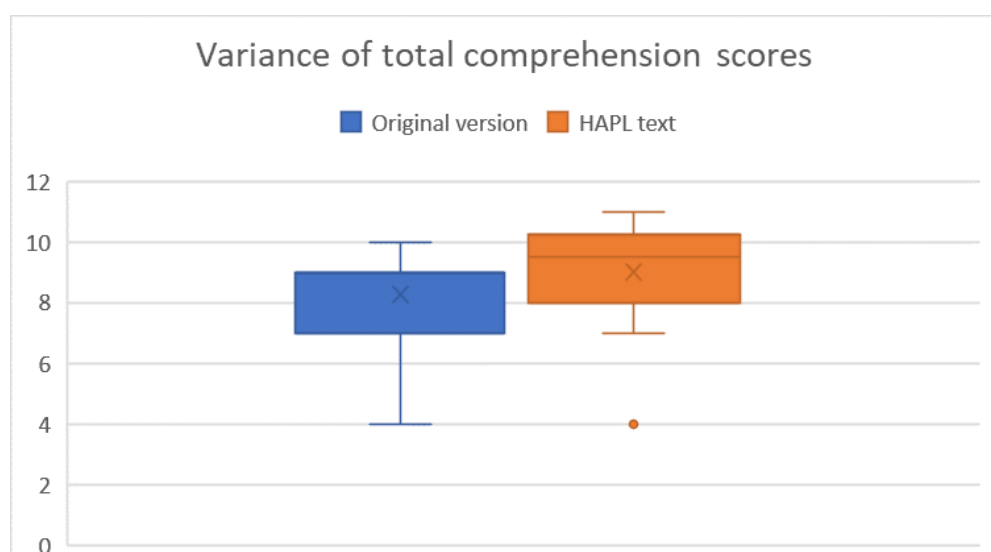
Graph 2: Total comprehension scores for both groups (in percent)



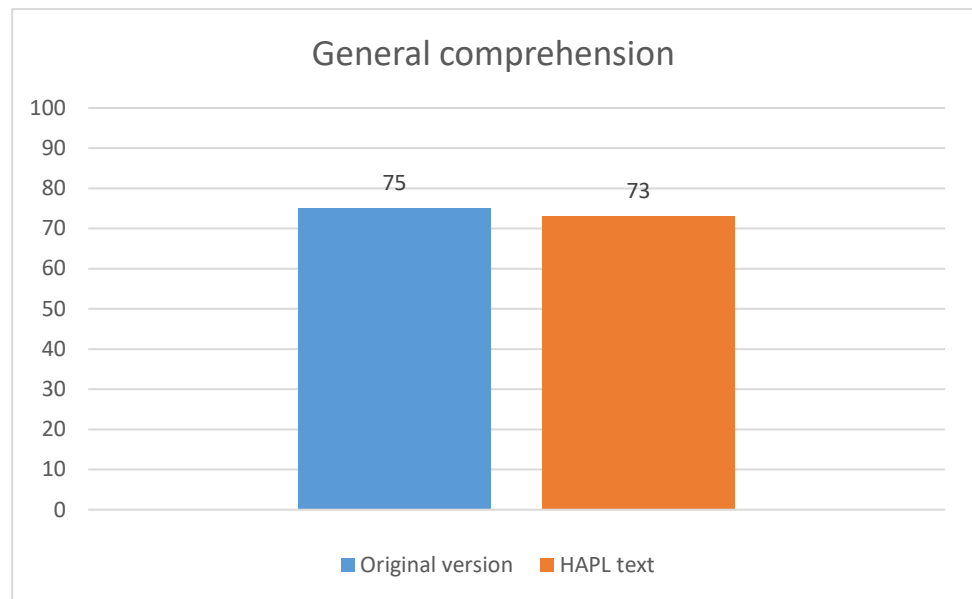
Graph 3: Frequency of correct answers of all test items



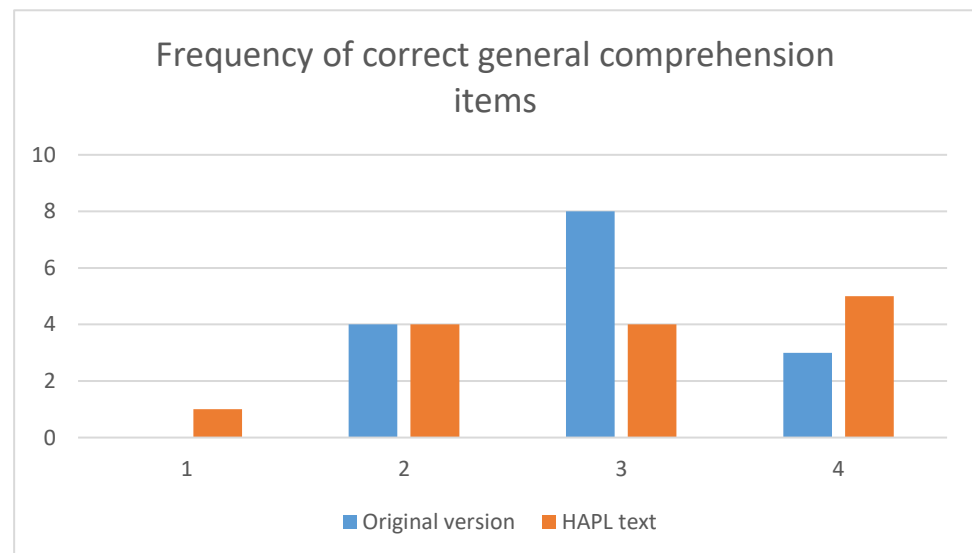
Graph 4: Variance of total comprehension scores (in correct answers)



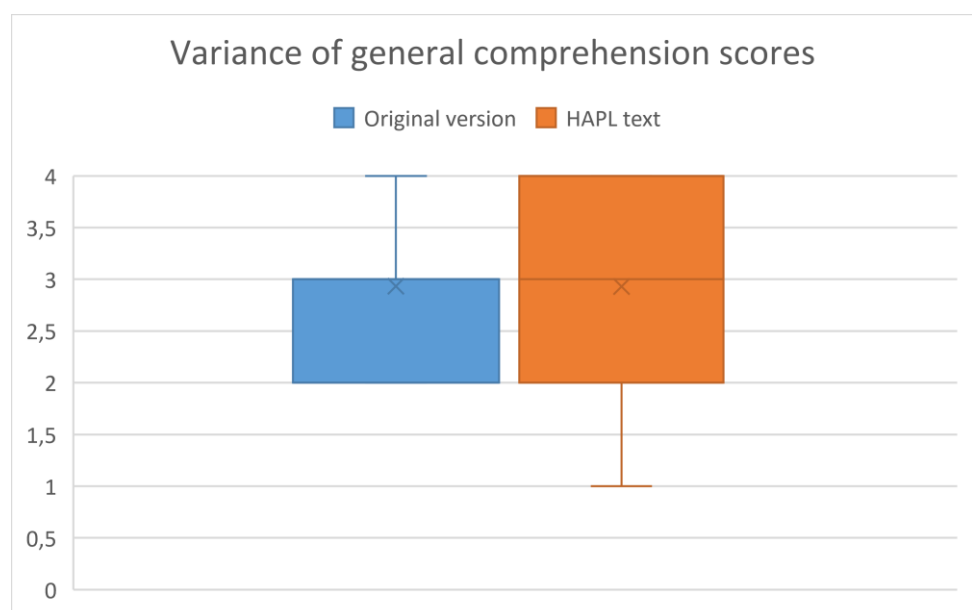
Graph 5: General comprehension scores (in percent)



Graph 6: Frequency of correct general comprehension items



Graph 7: Variance of general comprehension scores (in correct answers)



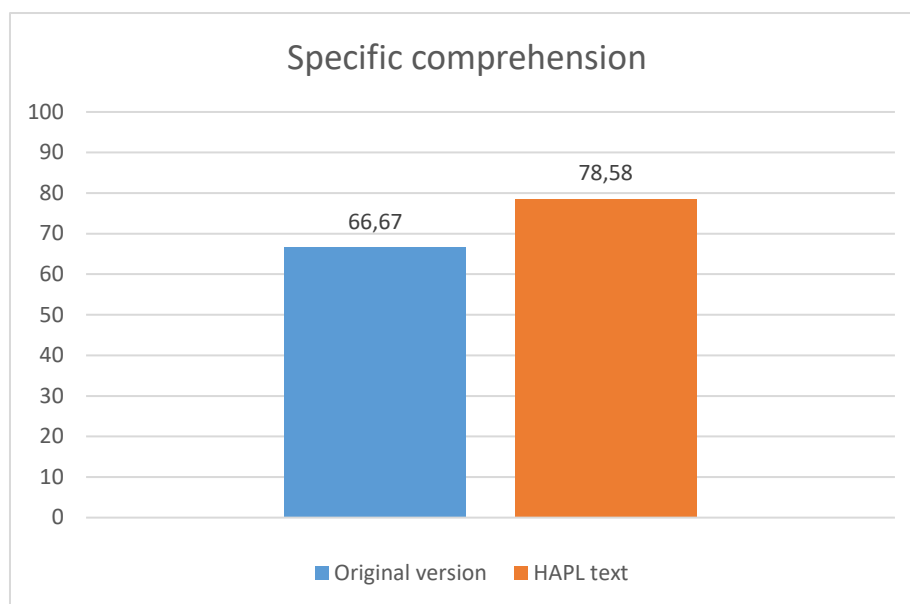
Concerning the specific comprehension, a nearly twelve percent increase has been observed (see graph 8). Graph 9 and 10 show that while both group's answers range from one correct answer to all four correct answers, the frequency of all correct answers is much higher in the HAPL group ($n=6$), versus the original group ($n=2$). Yet the t-test shows that the results are statistically not significant ($p = 0.08$). When it comes to other factors of descriptive statistics, the standard deviation of the scores from the readers of the original version is $SD = 0.89$ with fifteen students in that group ($n = 15$). The HAPL group shows a standard deviation of $SD = 0.95$ with only fourteen participants ($n = 14$).

Oh (2001) and Li et al (2005) differ in their results on this comprehension type as well. While simplification usually resulted in slightly higher scores in Oh's (2001) study, Li et al's (2005) participants with low proficiency performed worse when they were confronted with an elaborated text. This suggests that the participants of this study could have similar proficiency as Li et al's (2005) high proficiency group, since both studies suggest that simplification and elaboration can increase specific comprehension for this group. The reading comprehension test can be found in the appendix, and the specific comprehension questions have the numbers 2, 5, 6 and 10.

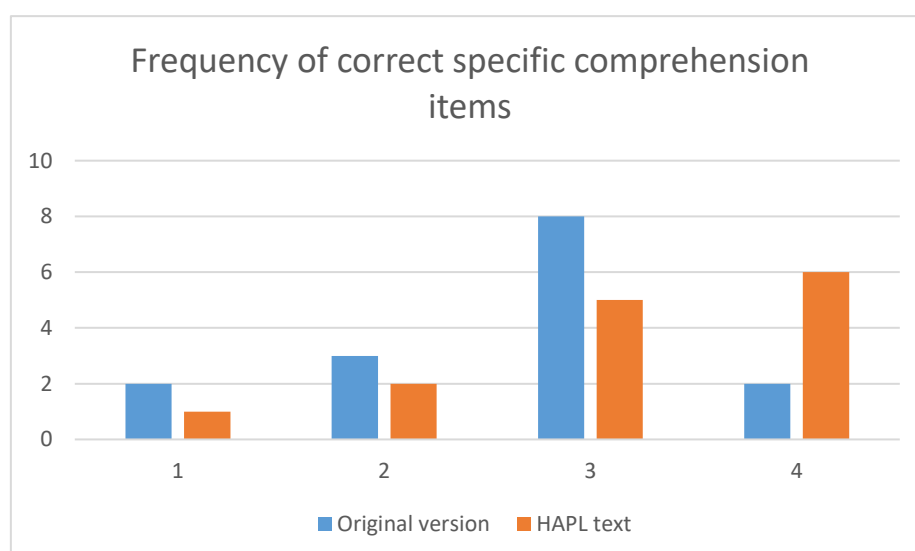
Regarding the students' performance on the inferential comprehension questions, an increase of 6,66% has been observed (see graph 11). The items which questioned inferential comprehension were 3, 7, 9 and 11. The inferential comprehension scores of the readers of the original version ($M = 2.67$, $SD = 0.74$, $n = 15$) was hypothesized to be smaller than the total comprehension scores of the HAPL readers ($M = 2.92$, $SD = 0.73$, $n = 14$). Since the t-test shows a result over 0.05, the difference in mean value cannot be seen as statistically significant. ($p = 0.17$). However, as graph 12 shows, again the HAPL readers dominate the category of having all four items correct and not a single student of the HAPL group scored zero or one point. This can also be seen in graph 13 in that the variance of the HAPL is smaller.

While Oh (2001), shows improvement for both kinds of input modification implemented in my study, Li et al (2005) showed a negative effect for elaboration. A similar instance has already been mentioned when discussing specific comprehension, although, concerning inferential comprehension it is not the performance of the low proficiency group that decreased, but the high proficiency group. If one compares the participants of the study at hand and their performance, they would resemble the low proficiency group's scores rather than the opposite group.

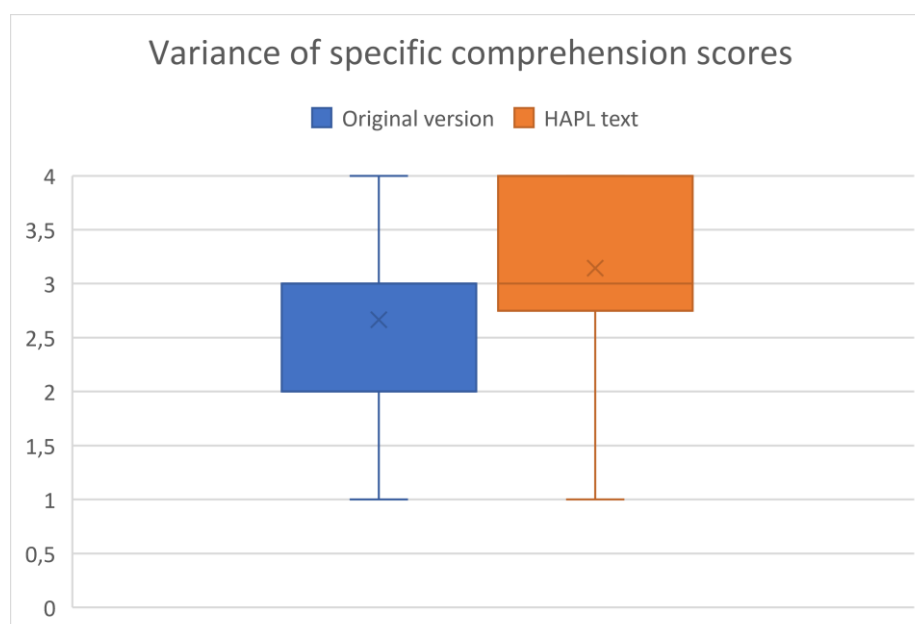
Graph 8:
Specific
comprehension
scores (in
percent)



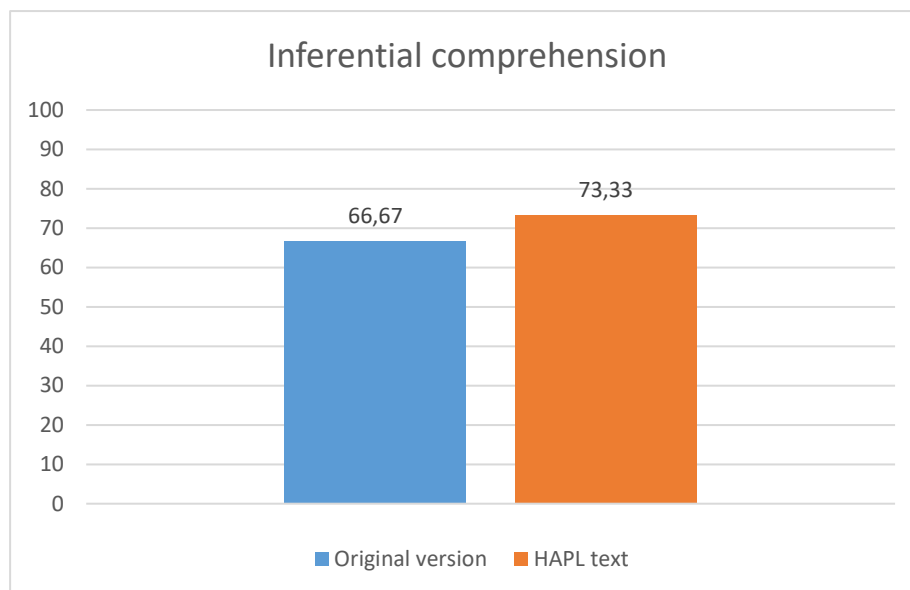
Graph 9:
Frequency of
correct specific
comprehension
items



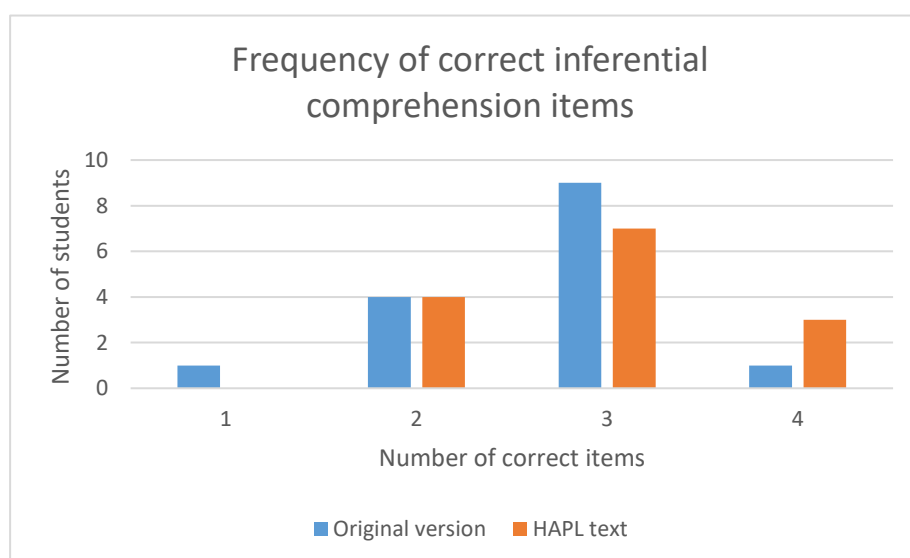
Graph 10:
Variance of
specific
comprehension
scores (in
correct answers)



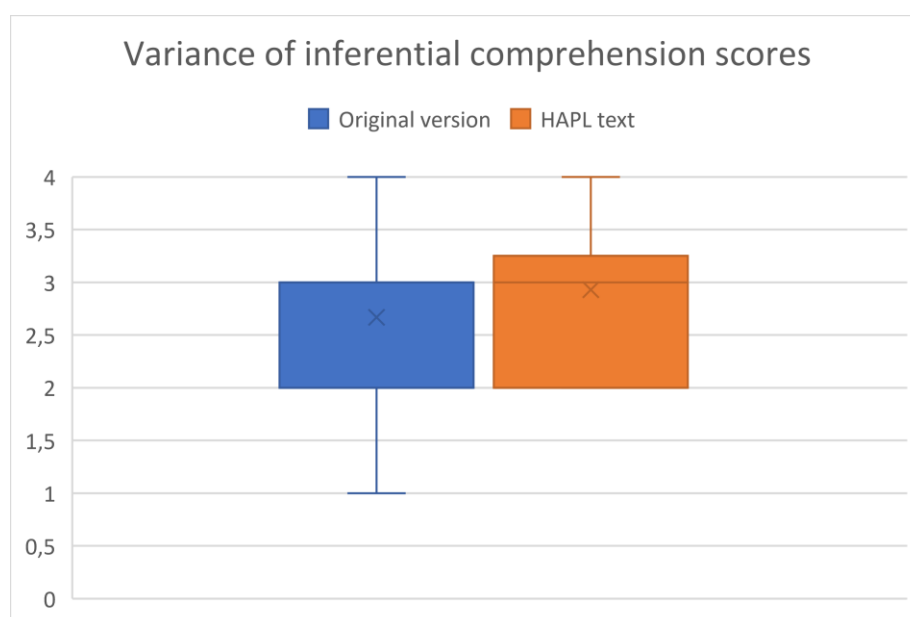
Graph 11:
Inferential
comprehension
scores for both
groups (in
percent)



Graph 12:
Frequency of
correct
inferential
comprehension
items



Graph 13:
Variance of
inferential
comprehension
scores

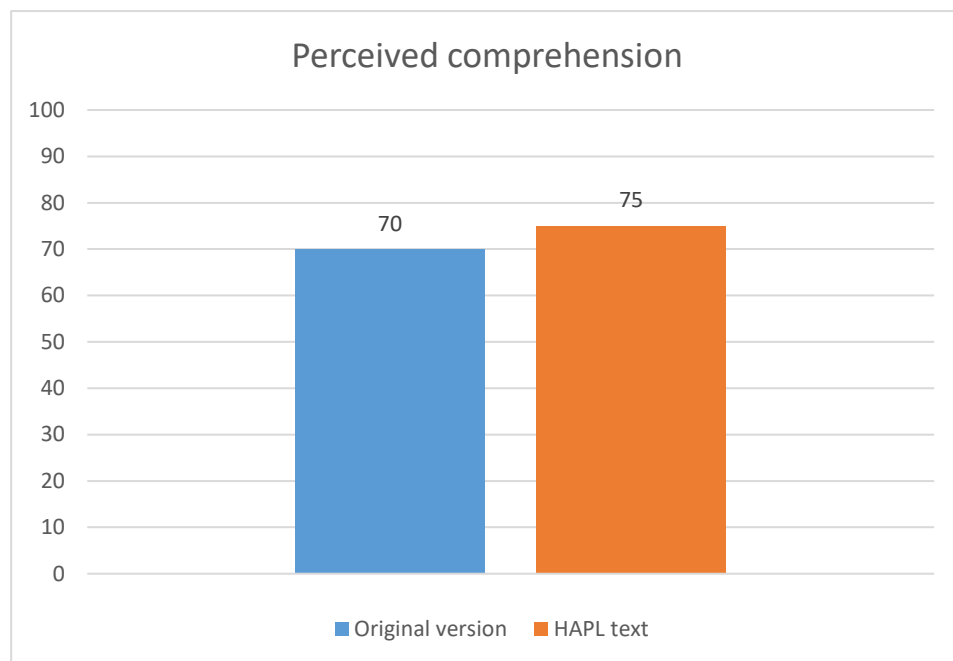


The perceived comprehension was tested as part of the questionnaire through the question “Wie viel Prozent des gerade gelesenen Textes, glaubst du, hast du verstanden?”. While the perceived comprehension scores increased from 70% to 75% (see graph 14), the difference in mean value is statistically not significant, but only a side-effect of different variances, according to the t-test result ($p = 0.23$). The standard deviation for the original version group is 21,71, whereas for the HAPL group it is 12,86. In graph 16 one can see why the standard deviation differs so much. None of the readers of the HAPL text thought that they had perceived less than 60% of the text. Graph 15 illustrates the variance of the perceived comprehension scores, which also emphasizes this difference. The readers of the original version stated that they perceived only 40 % of the text, while others of the same group thought that they had understood 100% of the text. In contrast to that, the range of the adapted version only spans from 60 to 100%.

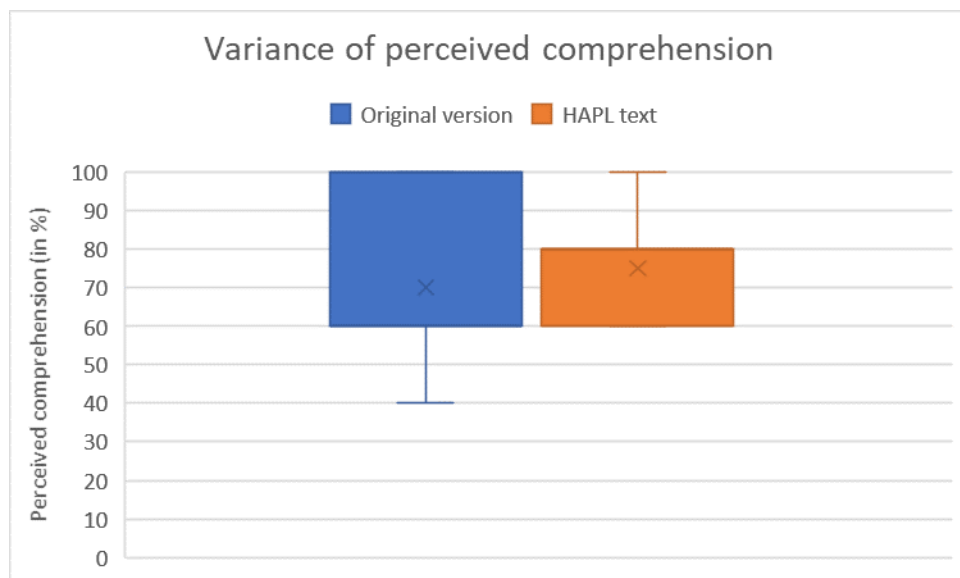
The slight increase of 5% due to the adaptation cannot be paralleled with both input modification studies. On the one hand, Oh's (2001) findings suggest that the elaborative aspect of the adaptation could lead to a small increase of the means of perceived comprehension, on the other hand, Li et al's (2005) study suggests that elaboration lowers perceived comprehension drastically. Therefore, one can presume that both the elaborative parts of the adaptation process for this study, and the simplification aspects could be possible factors that improved perceived comprehension scores.

In summary, while the means of most comprehension scores improved through the adaptation, the t-tests show that the differences of the mean values are not statistically significant. Yet, while the statistical insignificance shows the limitations of such a small-scale study, a slight trend in most comprehension types towards better comprehension of the HAPL text could be seen as supporting argument for reading HAPL instead of PSL in the classroom. The results clearly emphasize the need of a more detailed study with more than four test items per comprehension type and more participants. Still, in combination with the following analysis of the questionnaires, the benefits of HAPL will become clearer.

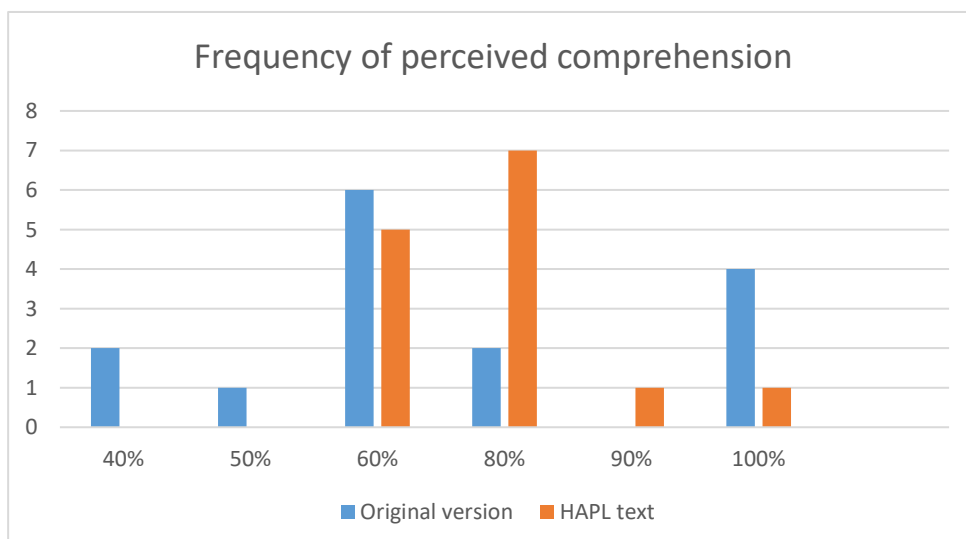
Graph 14: Perceived comprehension for both groups (in percent)



Graph 15: Variance of perceived comprehension (in percent)



Graph 16: Frequency of perceived comprehension

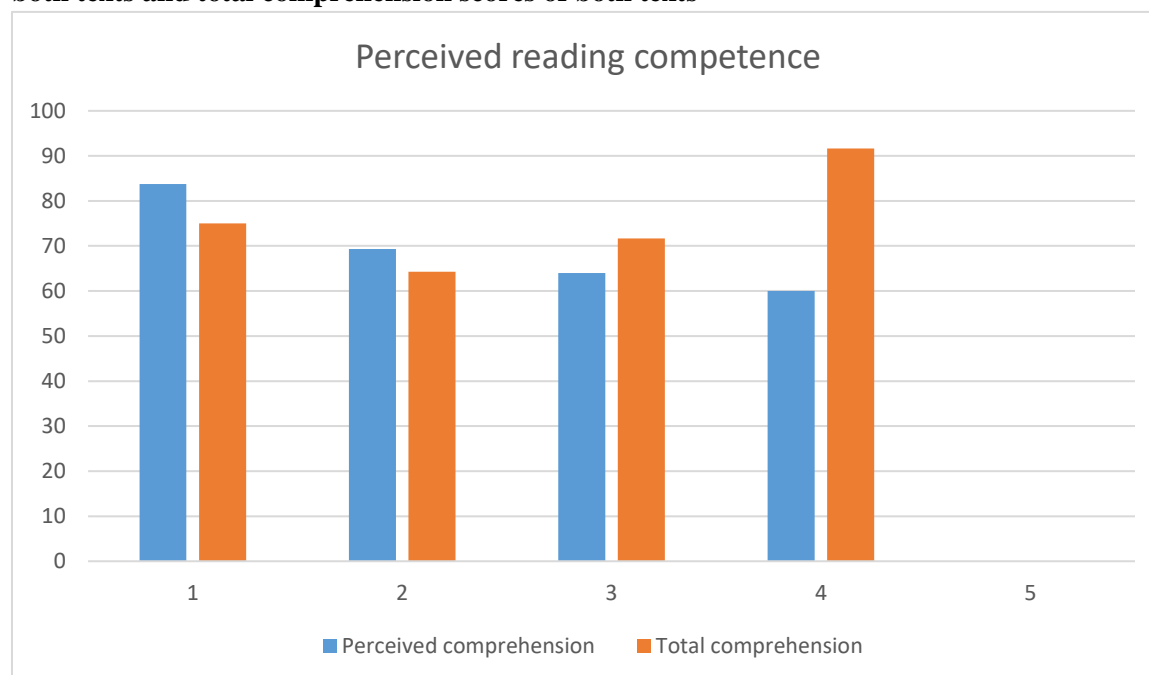


10.2. Analysis of the questionnaires

The items of the questionnaire are dealt with in the order they were presented to the participants. The first analytical step was to check for completeness, i.e. every question has an answer. Secondly, one has to check for accuracy, i.e. students answered the questions without any attempts to falsify the outcome. Another aspect that has to be analyzed is uniformity, i.e. questions were interpreted the same way by most students, and there have not been any ambiguous questions for them. These points can be answered by scanning through the questionnaires looking for joke-answers or answers that do not fit the question. After executing these steps, the questionnaires were analyzed, but not all items are topic of this section. The first questions that the students answered have already been mentioned in the chapter on the description of the participants. The last questions, including the open questions are discussed in chapter 10.3.

Perceived comprehension scores are closely linked with the question: “Wie gut bist du im Lesen von englischen Texten? Beurteile deine Lesekompetenz anhand von Schulnoten:”. Their own perception of their general reading competence will be compared with their perceived comprehension of the specific texts and their total comprehension scores in the next graph.

Graph 17: Cross-reference of perceived reading competence with perceived comprehension of both texts and total comprehension scores of both texts

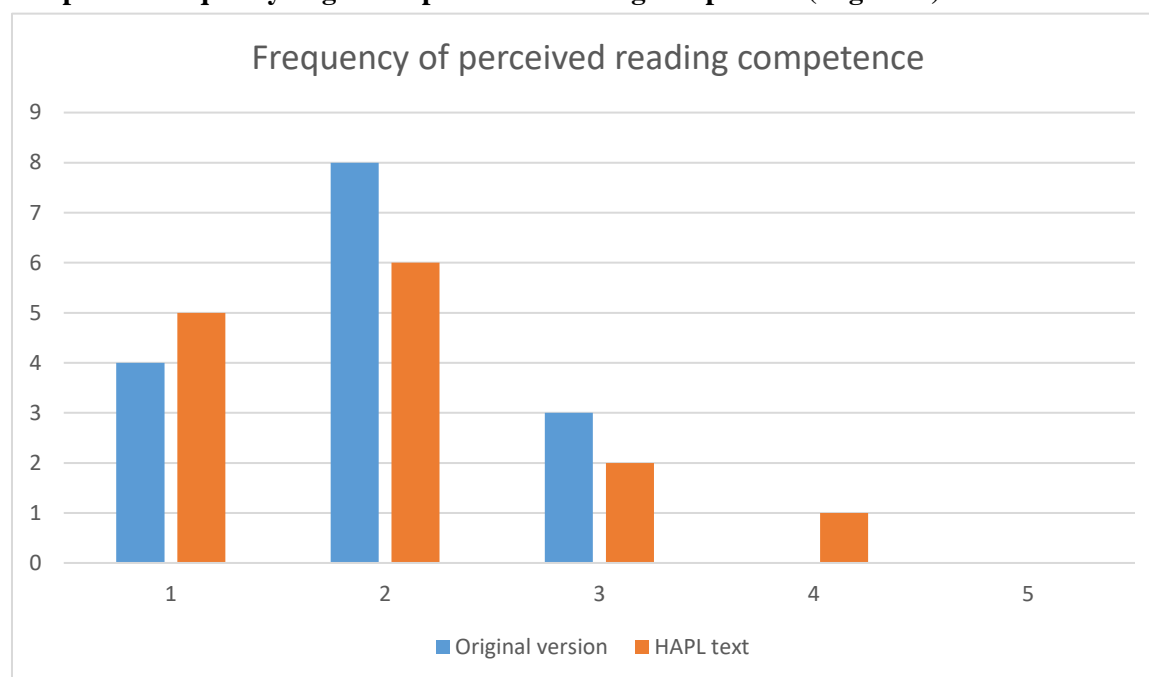


Graph 17 shows how well students could assess their own reading competence by combining the grade of the perceived reading competence with their actual comprehension result.

Additionally, the question of how much percent they thought they had perceived is also combined with the question of how well established their reading competence in general is.

As can be seen in the graph above, none of the participants stated that they would grade their reading competence in English with a five (the worst grade in the Austrian school system). Despite the interesting contrast between the grade four and the total comprehension scores of over 90%, it has to be mentioned that this category consists of only one student that assessed his own reading competence with the grade four, but still managed to get eleven out of twelve comprehension questions correctly. This can be seen in graph number 18.

Graph 18: Frequency of general perceived reading competence (in grades)



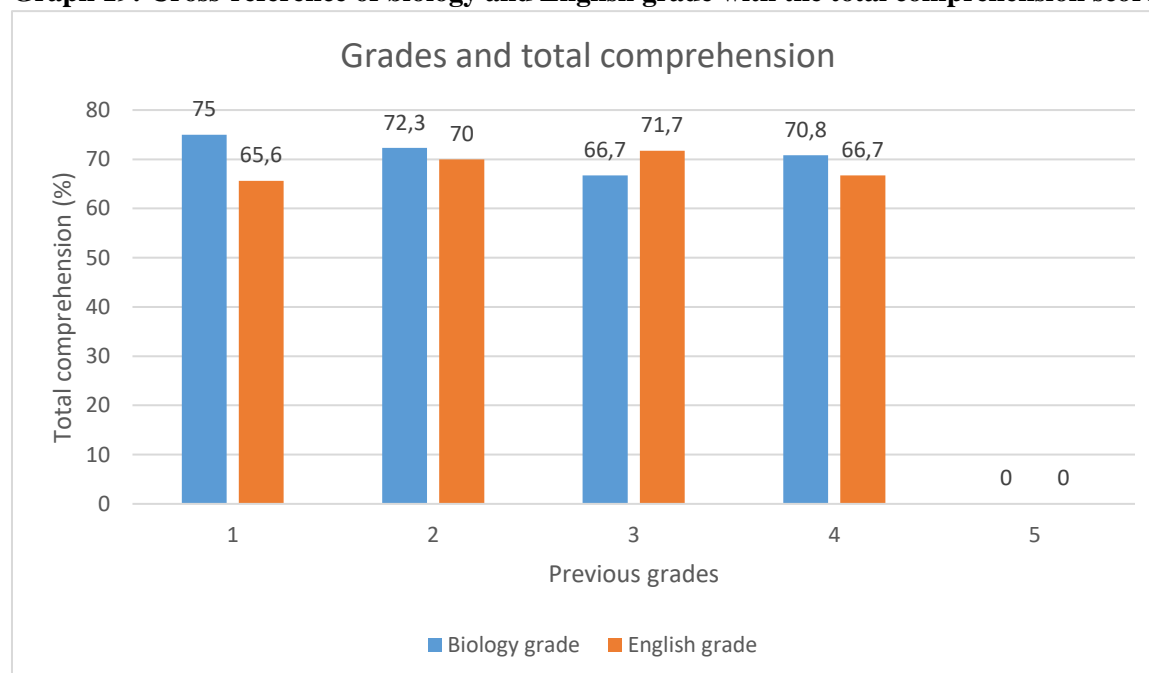
A lower perceived comprehension than the actual achieved total comprehension, is also the case for the group that stated their reading competences to be a three out of five. This can be interpreted in context with the students' confidence. If students thought that they had low reading competence, they also believed that they comprehended this specific text worse than they actually did. The opposite is the case when it comes to the students who stated that their reading competence could be described with a one or two out of five. The means of total comprehension scores of these groups were lower than the means of perceived comprehension. With fourteen participants choosing a two as their reading competence grade, this is the biggest group out of the five. It is also the one with the biggest variance concerning the total comprehension scores from 33,3% to 83,3 % and the biggest variance regarding the perceived comprehension, from 40% to 100%. With 64,3%, this group has the lowest mean of total comprehension scores. Nine students stated that they would grade their reading competence in English with a one, the best grade in the Austrian school system. As one can see in graph 17, the category of one has the highest mean of perceived comprehension scores, with 83,75%, while the total comprehension mean is, with 75%, not the best compared to the other categories.

In conclusion, the means of perceived comprehension scores of the texts show a declining trend in line with the students' self-assessment of their general reading competence in English. This is not the case for the actual total comprehension scores achieved by the students. In other words, the students who believed that they were bad at reading, also thought that they did not understand the text as well and vice versa, yet the results of the comprehension test do not support their evaluation of their own reading competence.

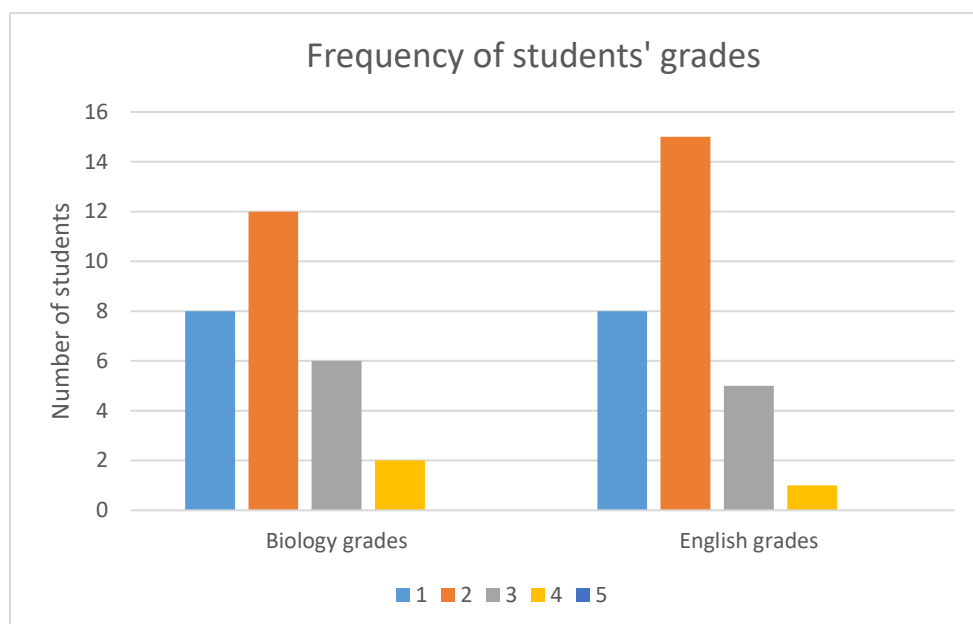
Graph 19 describes the correlations of the students' past grades in biology and English and the total comprehension scores. These parameters have been chosen to find a correlation between the comprehension scores and students' proficiency in either one of the subjects, English or biology. Graph 21 also depicts the variances of correct answers per grade. To explain why students with the grade 2 in biology or English seem to have a great variance in their total comprehension scores, another graph has been added that shows the frequencies of the different grades (see graph 20). This graph should illustrate that the difference in variance between, for example biology grades 2 and 4 is only a result of the lower number of students in the category 'grade 4'. For this example, the insignificance of the difference is also proven by the t-test ($p = 0.42$).

While Ardasheva & Tretter's (2018: 637) study showed that lower English proficiency is correlated with low reading comprehension scores of science texts and with low interest in science, no direct correlations between the performance on the reading comprehension test and the grades of the students could be observed in the study at hand. This leads to the conclusion that even the ones with problems in the general biology and English lessons were able to perform sufficiently on this reading comprehension test. Although, as one can see in graph ?, the number of students with grade four was only three, and not one student had had a five in the two subjects in the past year.

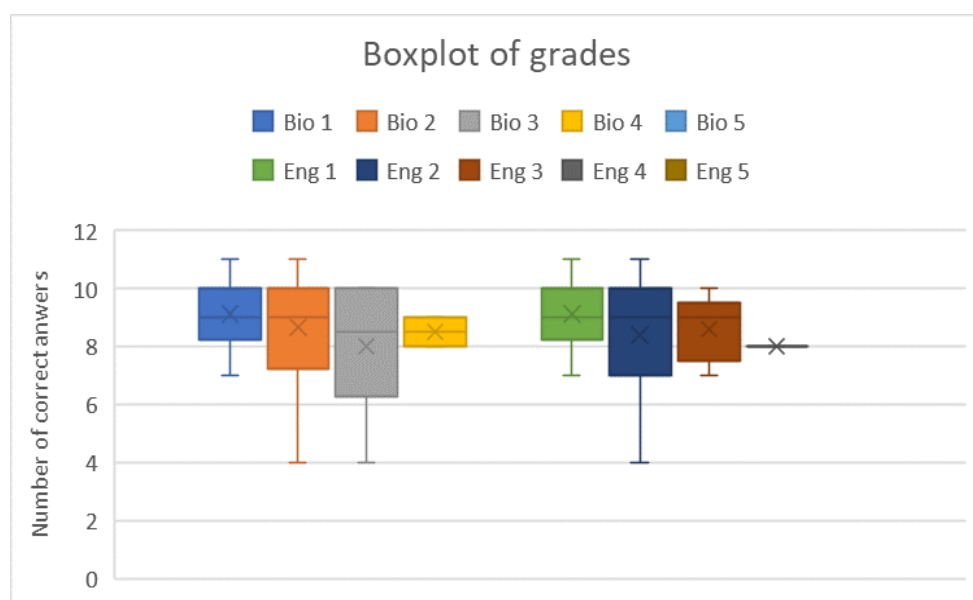
Graph 19: Cross-reference of biology and English grade with the total comprehension scores



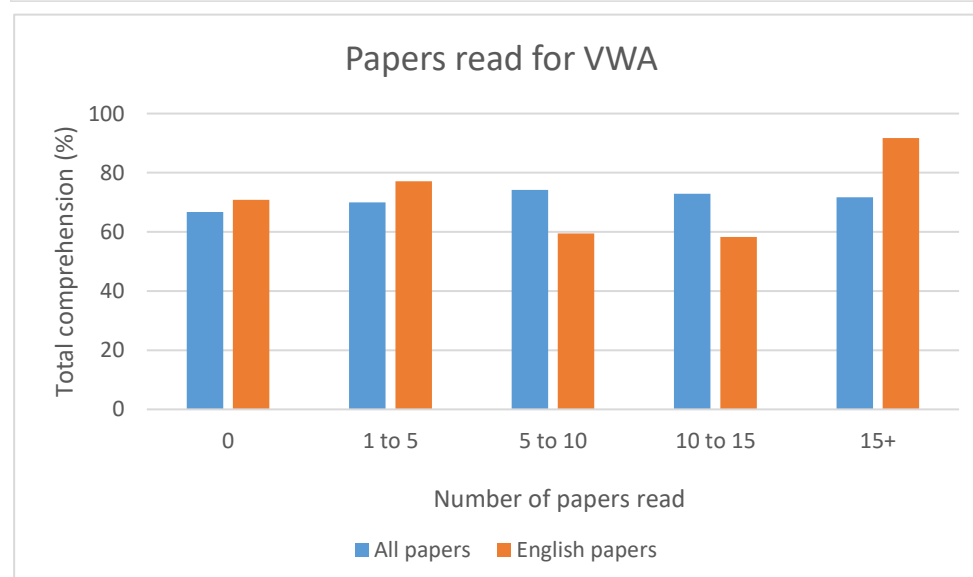
Graph 20: Frequency of students' grades



Graph 21: Boxplots of different grades

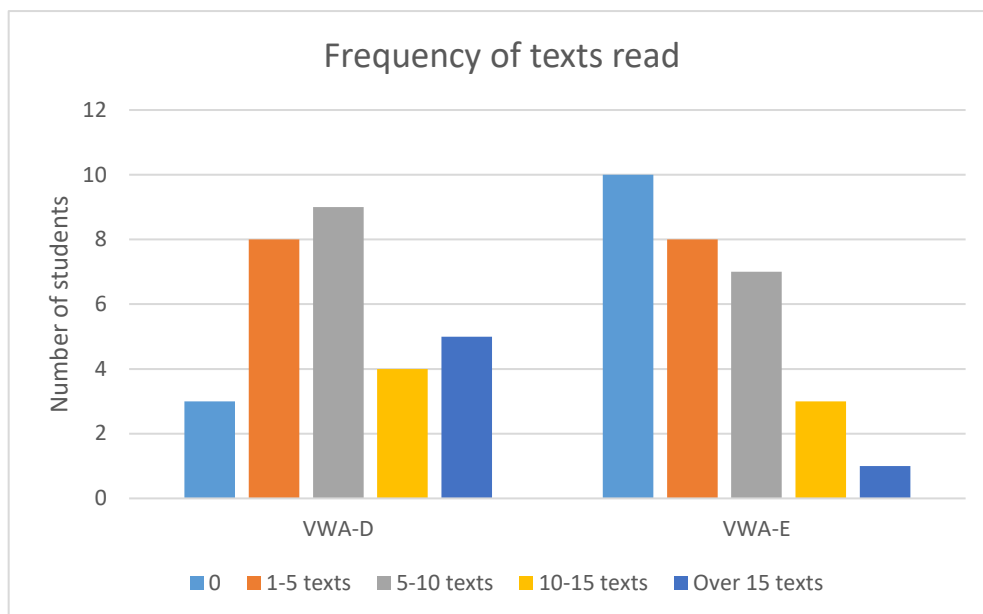


Graph 22: Number of academic papers read for the VWA cross-referenced with the total comprehension scores

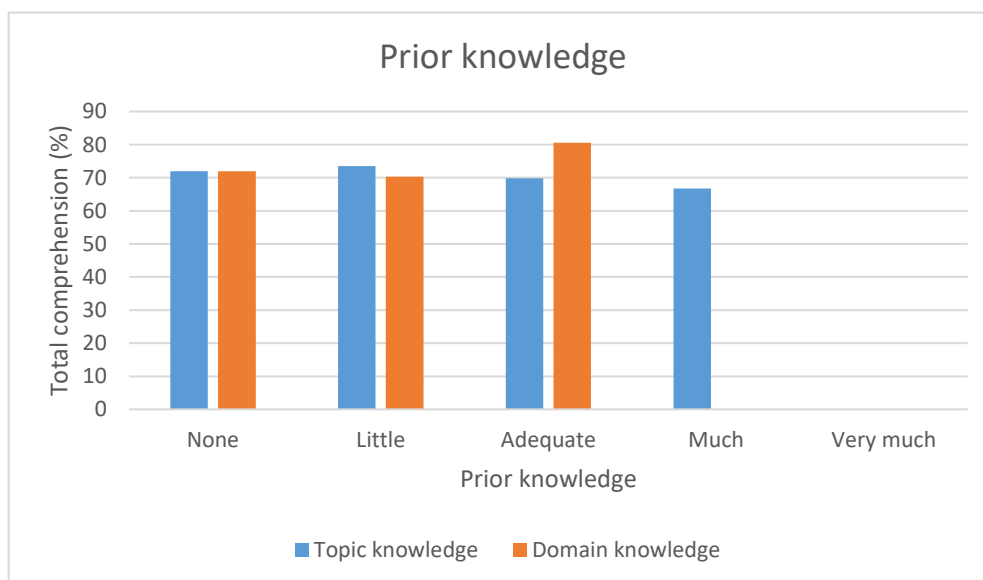


To understand the connection of previous experiences of reading research articles and the reading comprehension scores graph 22 depicts these two factors on its two axes. Graph 32 shows the frequency of the possible answers and reveals interesting findings. For example, only three students did not read any papers at all, but ten participants did not read papers written in English for their ‘Vorwissenschaftliche Arbeit’. It should also be mentioned that, on the other end of the spectrum, only one student stated to have read more than fifteen articles, while three students read more than fifteen papers in general, including the one that read the same amount in English. The one student who answered with 15+ for both categories was also one out of the two students that had written their ‘Vorwissenschaftliche Arbeit’ in English. Due to the very low number of English VWAs, the higher total comprehension these two students scored (80,3% in contrast to the overall 70,55% of all 29 students) cannot really support the generalization that students who write their VWAs in English learn to read PSL or HAPL texts better ($p = 0.22$). Yet one of these two students commented that she already knew much of the vocabulary mentioned in the glossary so writing one’s VWA in English might be beneficial for learning academic and scientific jargon. Eight students chose a topic with connections to the biology curriculum, and therefore, had to read scientific papers for their VWA. Topics that were categorized as biological included for example “Die kognitiven Mechanismen in der sozialen Interaktion von Schimpansen [The cognitive mechanisms of chimpanzees’ social interactions]”, or “Vergleichende Analyse von In-vitro Fertilisation und Intrauterine Insemination [Comparative analysis of in-vitro fertilization and intra-uterine insemination]”. These examples show the wide range of possible topics for the VWA which are connected to the biology teaching. The eight participants who were categorized into this group achieved a mean of total comprehension scores of 74% which is only 3,45% higher than the overall mean of total comprehension scores for both texts. The t-test of this difference in mean value results in a score higher than 0.05 ($p = 0.33$), and therefore, one cannot claim that this small increase shows that practice in reading scientific articles helps students in their comprehension of the same significantly. A comment of a student, however, supports the view that practice would help comprehension. She states that she has never read scientific articles, therefore it was hard to read and understand the content. In conclusion, the total comprehension scores show no trend that more read papers in English equals better comprehension. The students who read papers of the same field as the texts used in the study showed a statistically insignificant increase in total comprehension scores, yet a student’s opinion gives the impression that practice in reading might help comprehension.

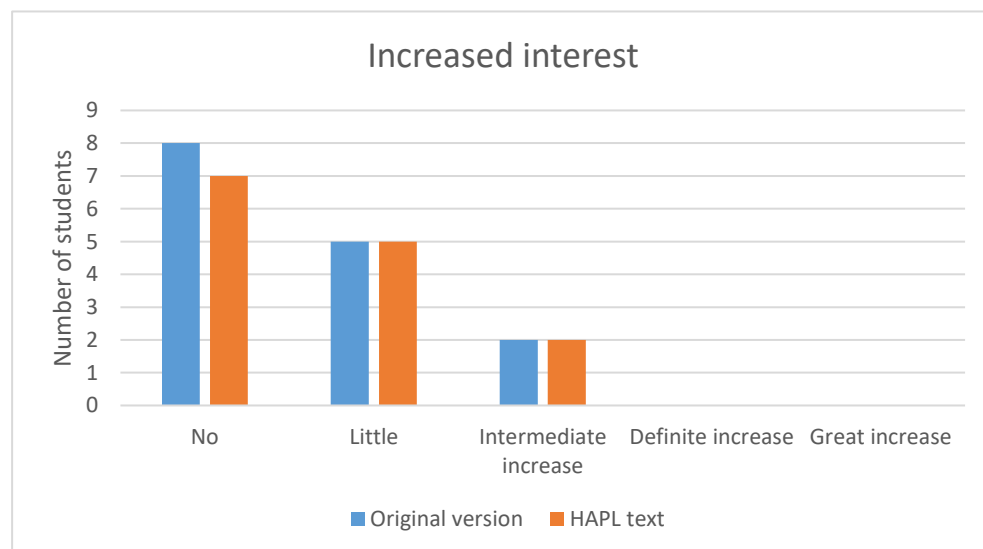
Graph 23:
Frequency of
academic texts
read during
research for
VWA



Graph 24:
Prior topic and
domain
knowledge
cross-
referenced with
total
comprehension
scores



Graph 25:
Frequency of
increased
interests

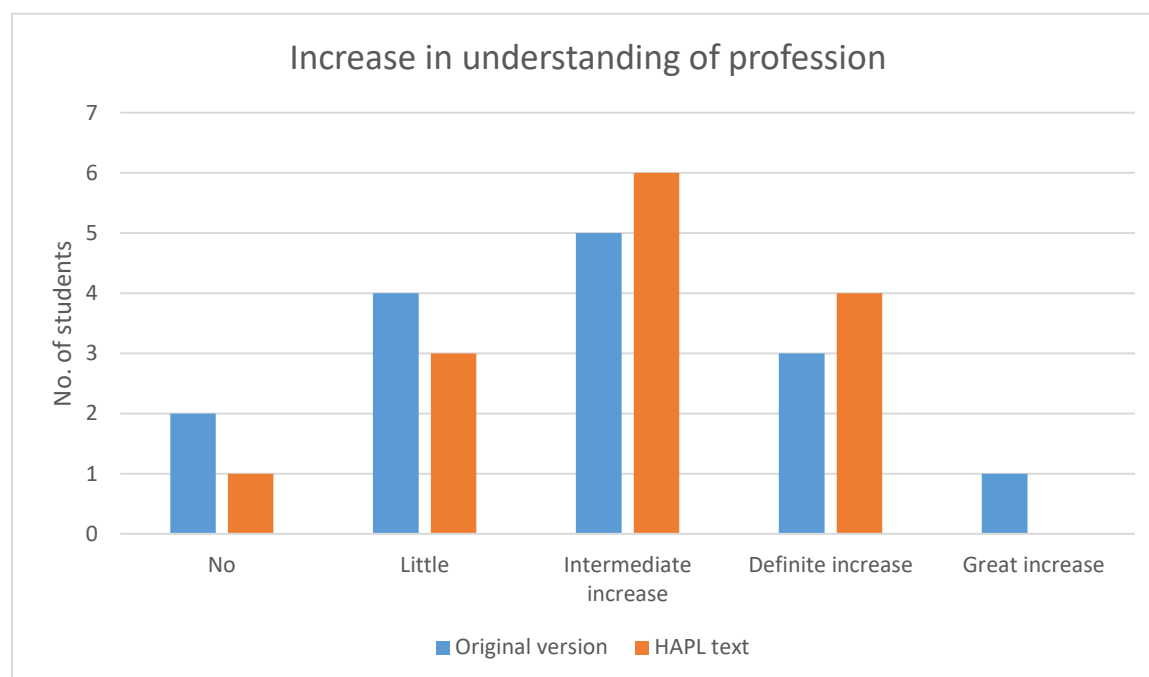


The correlations of the students' prior knowledge and their comprehension scores are depicted in graph 24. The domain knowledge about biotechnology and agriculture was not very high, since eight students stated that they had none, eighteen students stated that their prior knowledge in these domains was little before reading the text and only three stated that they had adequate prior domain knowledge. No participants claimed to have much or very much knowledge of this kind. Concerning the topic knowledge on genetically modified plants, a similar observation can be made. Eleven students had no prior knowledge on that topic, and the same number stated to have little knowledge about GMOs. Six participants claimed to know an adequate amount about the topic of the text, and only one chose the answer "much". Regarding the interrelationship with the total comprehension scores of the students, one might have expected an upward trend for students with more prior knowledge following the studies by Alexander et al (1994a, 1994b), however this could not be observed for this study.

Concerning the students' interest, Chen et al (2001: 386) mentions that responses to situational interest measures are often dependent on prior knowledge. Since my study was carried out in a high school, and not as many other studies in the field at the tertiary level, one can assume that individual interest could be lower, since the students are obligated to visit the biology lessons and have not chosen the subject out of intrinsic motivation. Since biotechnology is a new domain to the student, only dealt with in the 8th grade, it can be assumed that situational interest is high and individual interest rather low, according to the "stages of domain learning" postulated by Alexander et al (1994a: 316). However, as triggered situational interest is an essential first step in the development of individual interest (Ardasheva et al 2018: 639) this reading could have been the starting point of a lifelong hobby, or even career. This benefit was mentioned by a student in the questionnaire in which he states that the text was very informative, and that it triggered his interest to read more texts from the same area and learn more about it. This goes in line with Maltese & Tai (2010: 676), who studied the starting points of scientific interest, and 10% of female scientist and 14% of male subjects stated that their interest started during and because of their high school education. Additionally, 40 % claimed that their initial interest was sparked by school experiences. To test if Adapted Primary Literature can support the goal of fostering well-developed individual interest, the question "Hat dich der Artikel motiviert mehr über das Thema oder die Biologie als Wissenschaft zu lernen?" has been added to the questionnaire. Graph 25 shows that no difference in the increased interest in the topic between the original version and the HAPL text have been found. Both groups included two participants who stated that the texts increased their interest to learn more about the topic at a medium rate ("Mittelmäßig viel"). Five participants of each group, i.e. ten students, stated that their interest

in the topic and biology as a science increased a little (“Ein wenig”). The other fifteen of the students expressed that the texts did not increase their interest and motivation at all (“Keines”). With approximately half of the students without any increase in interest, the goal of enhancing students’ long-term motivation for the subject of biology, as suggested by Alexander et al (1994a: 334), could only be partly achieved with this reading task. The correlation of interest and learning postulated by Harp & Mayer (1997: 93) that the more readers understand a scientific text the more they are interested in it was not observed in the case of my participants.

Graph 26: Increase in understanding of the profession of a biologist for either the original version or the HAPL text



The graph above (number 26) shows the answers to the question “Hast du nach dem Lesen des Artikels ein besseres Verständnis für den Beruf eines/r Biologen/in?”. The trend is the same for both texts, resembling a bell-shaped curve with eleven students out of the twenty-nine claiming that their understanding of the profession of a biologist increased at an intermediate rate after reading the PSL or HAPL article. Learning features important to scientific professions is a goal of HAPL, however, a significant improvement in presenting those characteristics through the adaptation could not be observed. Shanahan et al (2009: 24) listed some important features, like “the connections between evidence and explanation in science, the personal motivation of scientists, the tremendous effort and time required for scientific research, and the place of research reports, not as repositories of absolute knowledge, but as reports of scientists making sense of available evidence to the best of their abilities”. Learning such scientific procedures

and thinking processes is also mentioned in the curriculum (Lehrplan 2004: 1). That this goal can be achieved through PSL and HAPL can be concluded from the answers to the question mentioned above.

In conclusion, some of the correlations of different student characteristics and their total comprehension scores show interesting connections, while most cannot be used to deduce a definite trend due to the size of the study. The students' perception of their reading competence seems to be in line with their perception of the comprehension of the specific texts, although, their actual comprehension scores are not linked with the former perceptions. No correlation has also been observed for the students' past English and Biology grades and their comprehension, therefore it seems that students with all grades have room for improvement when it comes to comprehending scientific texts. Regarding the students' experience with academic papers, the number of papers read was not correlated with the means of total comprehension scores. Having written the VWA on a biology related topic has not improved those students' comprehension scores significantly. Students that had written their VWA in English, however, had ten percent higher comprehension scores than the overall mean of total comprehension scores. When it comes to the need for prior knowledge for understanding a scientific article, neither topic nor domain knowledge seemed to have an effect on the comprehension of the specific text. Nevertheless, one should mention that prior knowledge in general was rather low in the participants. An increased interest in the topic was only observed in nearly half of the students, however, a greater understanding of the profession of a scientist was observed for most of the students. While this quantitative data is very interesting, a look at the students' comments is also worthwhile.

10.3. Discussion of the students' comments

While some of the students' comments have been part of the previous chapter, as they overlapped content wise with the quantitative results, other interesting remarks by students who answered the questions "Was war für dich schwierig zu verstehen?" and "Sonstige Anmerkungen:" will be dealt with in this section.

Problems students had with the PSL text included scientific and academic lexis, and the length of the passages and the text as a whole. Eleven students out of the fifteen that read the original version claimed that they had problems with the vocabulary. This stresses the importance of lexical modification. The problem of some students to keep being concentrated throughout

reading such a long text, which they are not used to, cannot really be helped with adaptation, since the length is an important feature of Primary Scientific Literature.

The students who read the HAPL version of the text also claimed that some lexical items were difficult for them, but one also mentions that due to the glossary these difficult words were rare. One student specifically mentions biological jargon to be a difficulty, and states names of species as an example. While some claimed that the adaptation, and the narrative addition in particular helped differentiating results made by previous research and Pascher's findings, two participants stated that they had problems with the tasks that required this differentiation.

When it comes to the effects of the narrative text which is part of the adaptation for the Hybrid Adapted Primary Literature, in contrast to Adapted Primary Literature, some interesting answers from the students are discussed in this paragraph. The students who read the HAPL text were asked to answer the question "Hat dir die Background-Box geholfen den Text und die Kommunikation zwischen WissenschaftlerInnen besser zu verstehen? Wenn ja, wie?". Two students simply wrote "No" as an answer, another said that it helped with at least one question of the comprehension test, and one said that it was not really helpful, just interesting additional information. The rest of the remarks were more positive and stated that the additional information was helpful in understanding the text and scientific communication. Some claimed it was helpful as an introduction, while some called it a summary or overview. The student who described the narrative text as an overview, stated that it helped their comprehension from the beginning on. Others explained the benefit as clarifying what Pascher's work was and what the work of others was. The identification of the newly introduced findings was also a problem for a student who read the original version.

To sum up, the main problem for students was the vocabulary of the text, which was partly improved through the lexical modification, especially the glossary. The addendum that makes the adapted version into an 'Hybrid Adapted Primary Literature', i.e. the background box, achieved its goal of highlighting the communicative aspect of research articles, at least for a part of the participants.

IV. Conclusion

The increasing language demands at universities and in the global research community affects the curricula of secondary schools. In science education, researchers reacted to the growing importance of the reading skill in their lessons through developing the field of Adapted Primary

Literature (APL), bridging the gap between real science and school science. Combining this approach with linguistic modification and setting it in the context of an Austrian CLIL biology classroom was the goal of this thesis.

The influence of CLIL can be observed in the addition of a narrative text, which makes the adapted version a 'Hybrid APL' and in changes concerning the communicative aspects of research articles. Before looking at the genre of the research article, one also has to discuss the theory of reading in general and factors that can influence comprehension. The literature on this topic mainly influenced the selection process and the development of the reading comprehension test and questionnaire. The theory of Adapted Primary Literature was mostly used for the adaptation of the structure, content and the selection process for the Primary Scientific Literature article which was adapted into an HAPL article. The theory of input modification was implemented mostly on the sentence level, with lexical modification and syntactic simplification being complex and important steps of the adaptation. The selection process has led to the choice of Pascher (2016) as PSL text, which was then adapted for the use in an Austrian CLIL biology classroom.

The empirical study was conducted in the Brg 14 Linzerstraße, with 29 participants attending their twelfth year of schooling. Pascher (2016) was used as exemplification for applying the theoretical guideline of the adaptation process on a PSL text. The research questions included, if the newly created Hybrid Adapted Primary Literature text increased reading comprehension scores of secondary school students. The results showed a slight increase in total comprehension scores, however, with differing results regarding the types of comprehension, and due to the small-scale of the study the need for further research is the main conclusion of the empirical part. Concerning the correlations of prior knowledge and interest and the comprehension scores, no clear trend could be observed. This leads to the conclusion that for the case of the PSL article chosen for the study, prior knowledge seems not to influence comprehension. When it comes to the question of increased interest, approximately half of the participant claimed to have gained increased interest in the topic; however, the adaptation could not improve that aspect of reading. One reason for implementing HAPL into biology teaching is the need for students to be able to read PSL for their 'Vorwissenschaftliche Arbeit', and HAPL is a way to scaffold the learning of necessary reading skills. While the quantitative data does not support the notion of a significant increase in reading comprehension due to the experience in reading scientific articles, the students' comments suggest that a complete lack of knowledge about this genre does hinder comprehension, and an extensive practice in reading the genre makes the

comprehension easier. As this is only a small scale study, further research is needed establish a more detailed picture of the benefits and limitations of APL in the Austrian school system.

In general, it can be concluded that the use of Hybrid Adapted Primary Literature is a valid method for bridging the gap between real science and school science and can introduce students to the world of scientific research. The overlaps of the goals of quality CLIL teaching with the goals of HAPL and the benefits of this method identified through the empirical study, both support the inclusion of HAPL in the Austrian CLIL biology classroom.

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Text A: Pascher, Kathrin. 2016. "Spread of volunteer and feral maize plants in Central Europe: recent data from Austria". *Journal of Environmental Science Europe* 28(1), (no page nr).

Text B: Hybrid Adapted Primary Literature version of Pascher (2016)

DISCUSSION

Open Access



Spread of volunteer and feral maize plants in Central Europe: recent data from Austria

Kathrin Pascher*

Abstract

The occurrence of volunteer maize plants in subsequent crops as well as of feral maize plants in non-agricultural areas is an essential issue in risk assessments of genetically modified (GM) maize, with regard to possible contamination of natural habitats with GM material and as contribution to the total adventitious GM content of the non-GM final product. The appearance of feral maize plants has been confirmed for non-agricultural habitats in European areas with Mediterranean climate such as Spain. However, the existence of maize volunteers and feral maize outside cultivation under Central European continental climatic conditions is considered to be extremely unlikely in those winter-cold areas. Here, field observations during 5 years (2007, 2008, 2010, 2011 and 2015) in Austria are presented that confirm the occurrence of volunteer and feral maize under Central European climatic conditions. Most of these plants produced fertile inflorescences with viable pollen and fully developed cobs. Maize kernels may reach the soil by disintegration of cobs due to disease, using crushed maize cobs for game-feeding, left overs in manure dispersed during fertilisation or from transporting and handling of crushed cobs. The evidence of volunteer and feral maize in four Federal States in Austria (Burgenland, Lower Austria, Upper Austria, Styria) emphasises the necessity to consider these hitherto under-emphasised factors in an ecological risk assessment (ERA) of GM maize as a possible source for transgenes in non-agricultural habitats, because these plants could act as bridge for the spread of GM material into semi-natural habitats. In accordance with the European Food Safety Authority (EFSA), which states that in principle maize has the potential to survive as a volunteer or feral plant also in regions with cold winters, the investigation of the frequency of their occurrence under Central European conditions should be part of future monitoring programmes in order to assess their potential for permitting transgene spread.

Keywords: Maize, Corn, Genetically modified (GM), Feral plants, Volunteers, Central Europe, Transgene spread, Field observations, Ecological risk assessment (ERA), EU legislation

Background

Maize (*Zea mays* subsp. *mays*) is an annual monoecious crop frequently grown in many countries. In 2014, a total area of 184 Mio hectares was cultivated worldwide (<http://faostat3.fao.org/download/Q/QC/E>, accessed 24th of July 2016). Currently, around 30% of maize is genetically modified (GM) [1]. In 2014, 143,016 hectares of biotech Bt maize Mon810 have been cultivated in the

EU, mainly in Spain. Transgenic maize for commercial production confers either insect resistance or herbicide tolerance or a combination thereof. This crop is mainly used for food and livestock feed, but also for renewable resources. Maize, domesticated by native Indians of Mexico and northern Central America already about 5500 years ago [2], has been introduced to Europe in 1525 owing to the discovery of America by Columbus. Since then, a large number of local varieties have been developed all over Europe. This crop has also been subject to trait improvement via genetic modification since several decades. In case of cultivation of GM maize, the main factors that determine adventitious presence of a

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genetically modified organism (GMO) in non-GM material are unintended seed impurity, seed planting equipment and practices, cross-pollination between GM and non-GM crops, the presence of GM volunteers, and product mixing during harvest, transport and/or storage processes [3]. Moreover, due to the current focussing in breeding, improvement and use of only a few crop varieties, the diversity of maize landraces could be threatened in future. Cross-pollination is possible in areas with hybridisation partners such as Mexico. However, teosinte—the closest relative of maize—has recently been detected also in Spain where it behaves like an invasive weed of agricultural land (http://www.agpme.es/index.php?option=com_content&view=article&id=181:el-teosinte&catid=44:articulos&Itemid=68, accessed 30th of July 2016). Even though maize is a mainly wind-pollinated crop [4], it has also been observed to function as pollen source for honey bees [5]. So, non-target organisms that collect pollen of maize plants are exposed directly to GM pollen. Additionally, volunteer and feral maize plants contribute to a prolonged GM pollen exposure. Hence, the relevant environmental aspects of volunteer and feral maize include uncontrolled dispersal of GM plants into the environment, prolonged exposure of non-target organisms to GM pollen, increased use of herbicide to remove volunteer and feral maize and an adopted insect resistance management that is mandatory for Bt crops. In the USA, volunteer maize growing in soybean fields above the soybean canopy is known as a highly competitive weed and requires specific herbicide application [6].

It is controversially debated among European scientists, stakeholders and policy makers, whether maize volunteers in subsequent crops may pose a problem also in colder climatic zones of Europe. Moreover, it has been questioned, if maize has the ability at all to become feral outside cultivation in areas with cold winter temperatures and how the likelihood of becoming feral has to be rated under Central European continental climate conditions compared to those in Mexico. Some scientists assume that maize as a highly domesticated crop has very little invasion potential and poses a negligible ecological risk [7]. Maize seeds and seedlings are assumed to survive the winter only in southern European countries, such as Spain, where maize kernels that remain on the soil after harvest can germinate and develop into flowering individuals, which can locally cross-pollinate neighbouring maize plants [8]. However, by a combination of weak growth, asynchronous flowering with the maize crop, low resistance to frost, low competitiveness, absence of a dormancy phase, susceptibility to diseases, herbivory and cold climate conditions survival of the plants is estimated to be unlikely, rendering the risk for outcrossing

and establishment of populations limited [3, 9, 10]. So far, there have been no records for survival of volunteer and feral maize plants in the Netherlands [11]. Occasional records for maize growing outside agronomic conditions on the British Island have been made, but are rare [12, 13]. Irish maize varieties, while cold adapted, were observed to be still frost intolerant [14]. However, single plants were registered in two Irish port locations, Limerick and Dublin [15]. In contrast, in an American study, several volunteer maize kernels were found to be winter-hard in northern latitudes and germinated the following spring [16]. Even in Germany, GM volunteer maize plants—containing the Nos-terminator and the CaMV35S-promotor—were recorded for the first time on a field of Monsanto in Nordrhein-Westfalen in 2007 (http://www.proplanta.de/Agrar-Nachrichten/Wissenschaft/GVO-Mais-ueberwintert-erstmal-in-Deutschland_article1185528877.html; <http://www.zeitpunkt.ch/news/artikel-einzelansicht/artikel/durchwuchs-gentech-mais-ueberwintert-erstmal-in-deutschland.html>; http://www.haerlin.org/Mais_Durchwuchs.pdf, accessed 24th of July 2016). The GM maize had been seeded in 2006 and several seeds obviously survived the mild winter temperatures in 2006/2007. It is stated that climate change could be a driving force for overwintering of maize seeds in future.

The term “to become feral” in the context of a crop refers to the crop’s occurrence outside cultivation. The invasiveness potential of a crop is the likelihood that it will persist and spread in non-agricultural habitats [7]. Ecological harm in connection with a GMO includes that the transgenic crop produces seeds, which then disperse to non-agricultural habitats, that the crop establishes in the non-agricultural habitat and forms a self-sustaining population. If feral plants spread and thereby influence the abundance of native species, they will cause ecological harm [17–19]. It is often argued—because no visible ecological harm has been identified during the long history of cultivation of the conventional crop-type—that there would be no negative effect originating from the GM crop. It is assumed that the chain of the above listed events from cultivation to ecological harm is obviously broken at one or more links [7]. An Irish Study [14] says:

“Evidence for this can be seen in the lack of anecdotal evidence supporting the existence of feral maize populations. It is safe to conclude therefore that under current climatic conditions and in the absence of selection pressure there is no likelihood of GMHT maize persisting over adjacent flora and hence there would be no detrimental impact on the Irish landscape should GMHT maize seed be lost pre-sowing”. Also the Organisation for Economic Cooperation

and Development, OECD, is very sceptical towards a potential invasiveness of the crop maize [20]:

“Volunteers are common in many agronomic systems, but they are easily controlled; however, maize is incapable of sustained reproduction outside of domestic cultivation”. The Netherlands Commission on Genetic Modification, COGEM [11] states:

“During its long domestication process, maize has lost its ability to survive in the wild. In the Netherlands, the appearance of maize volunteers is rare and establishment of volunteers in the wild has never been reported. There are no reasons to assume that the introduced trait will increase the potential of maize to establish feral populations”. Contrastingly, other scientists consider volunteerism and fertility of maize as at least in principle possible [3, 21, 22]. Even the European Food Safety Authority (EFSA) gives the following statement concerning the occurrence of volunteer maize:

“Maize is highly domesticated and generally unable to survive in the environment without management intervention. Maize plants are not winter hardy in many regions of Europe; furthermore, they have lost their ability to release seeds from the cob and they do not occur outside cultivated land or disturbed habitats in agricultural landscapes of Europe, despite cultivation for many years. In cultivation, maize volunteers may arise under some environmental conditions (mild winters). Observations made on cobs, cob fragments or isolated grains shed in the field during harvesting, indicate that grains may survive and overwinter in some regions, resulting in volunteers in subsequent crops. The occurrence of maize volunteers has been reported in Spain and other European regions” [8, 23].

The present article will contribute to the debate whether maize is able to become feral and to exist as a volunteer plant in Central Europe, exemplarily shown with Austrian data. In Austria, a temperate Central European transition climate is predominant with a continental climate in the east of the country and influences of the oceanic climate in the west. Large climate differences exist between the moderate climate in the Alpine north and the Mediterranean influences in the Alpine south. Austria is rich in diversity of landscapes and of animal and plant species [24, 25]. A release of GM crops has been performed neither for field experiments nor for cultivation in this EU member state. Several proofs (photographs taken during fieldwork) of the occurrence of

volunteer and feral maize plants in Austria will be presented here.

Methods

All records reported here were made by accident during fieldwork for three studies in Austria. The study BINATS [25] covered altogether 100 test areas, each 625×625 m in size; 50 test areas were located in maize cultivation regions (Lower and Upper Austria, Burgenland, Styria, Carinthia) and 50 in oilseed rape cultivation regions (Lower and Upper Austria, Burgenland). For selection of test areas, a stratified random sampling procedure for monitoring biodiversity in the Austrian agrarian regions was applied, including criteria such as diversity of soil types, forest cover in close proximity to the test area, grassland cover, average annual temperature or average annual precipitation. In the study FEAR [26], 50 potato fields and 50 maize fields were selected randomly, but representative for the extent of cultivation and diversity of soil types in the Austrian potato and maize cultivation regions. The maize fields investigated for FEAR were located in the 50 BINATS maize test areas. The maize growing region of Lower and Upper Austria were sampled more intensively than those of the other Federal States (Burgenland 6, Styria 4, Carinthia 2). Similarly, most sampling sites from the potato growing area were from Lower and Upper Austria, fewer fields were investigated elsewhere (Styria 3, Tyrol 3, Burgenland 1, Salzburg 1). For the third study, dealing with imported oilseed rape [27], 60 investigation sites were selected all over Austria including presumable hotspots for seed spillage such as switchyards (2), border railway stations (6), main ports (3), OSR importing oil mills (3) and an OSR processing facility (1) as well as randomly selected road sectors (2 kilometres; 22), railway stations (20) and small ports (3). Most of the sites were located in those Federal States where oilseed rape is mainly grown (Upper Austria 25, Lower Austria 11, Burgenland 2), fewer in the other Federal States (Salzburg 7, Styria 5, Tyrol 4, Vorarlberg 4, Carinthia 1, Vienna 1). As none of the sampling sites had been selected on expectations for the occurrence of volunteer and feral maize, the data presented here provide anecdotal evidence for the existence of volunteer and feral maize under Central European conditions at several locations in Austria and in several years, but they do not allow any assessment on regional distribution and abundance to be made.

Results and discussion

Occurrence of volunteer and feral maize plants in Austria

Volunteer maize plants were observed in two potato fields in Styria as well as in a soybean and a pumpkin field in Lower Austria in summer 2011 (Figs. 1a–e, 2) during

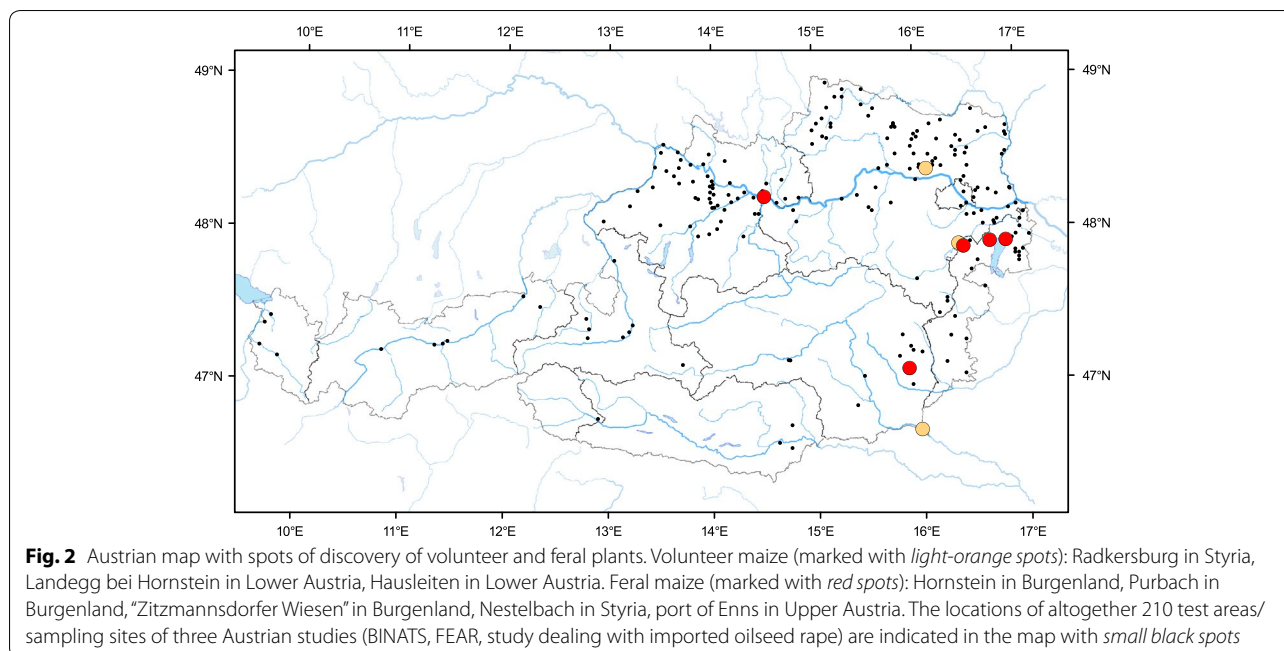


Fig. 1 Observations of volunteer (**a–e**) and feral (**f–p**) maize in Austria. Volunteer maize: **a–c** potato fields near Bad Radkersburg in Styria (7th August 2011); **d** soybean field in Landegg close to Hornstein in Lower Austria (11th August 2011); **e** pumpkin field in Hausleiten in Lower Austria (9th September 2011). Feral maize: **f** Hornstein, Burgenland (18th August 2007); **g** and **h** Purbach am Neusiedlersee, Burgenland (12th August 2008); **i–k** at the edge of the “Zitzmannsdorfer Wiesen”, Neusiedlersee, Burgenland (19th August 2010); **l** and **m** Nestelbach, Styria; **n** and **o** loading area in the port of Enns, Upper Austria (12th August 2015); **p** pile of sand located in the port of Enns, Upper Austria (12th August 2015), moreover feral oilseed rape plants could be observed on the pile

field sampling in the course of the project FEAR [26]. Several of the volunteer plant individuals found—seven and ten, respectively—flowered and had already produced vital cobs.

Feral maize plants were observed in three Austrian Federal States (Burgenland, Styria and Upper Austria; Fig. 2) in August in the years 2007, 2008, 2010 and 2015 during

fieldwork for three studies [25–28]. Most of the feral plants—one individual in Hornstein (Fig. 1f; Burgenland); two individuals in Purbach am Neusiedlersee (Fig. 1g, h; Burgenland); around 30 individuals at the “Zitzmannsdorfer Wiesen” (Fig. 1i–k; Burgenland); six individuals in Nestelbach (Fig. 1l, m; Styria); three individuals at the unloading area of the port of Enns (Fig. 1n, o, Upper



Austria) and three individuals on a sand pile at the port of Enns (Fig. 1p)—were fertile and had already produced cobs. Particular emphasis has to be put on the observation of the highest number of observed feral maize plants on the edge of the “Zitzmannsdorfer Wiesen” as this area is part of the National Park Neusiedler See—Seewinkel. Like the locations Hornstein and Purbach, the National Park belongs to the Pannonian climate region. As can be seen in Fig. 1i–k, the plants have grown on a rather open site together with the black locust (*Robinia pseudoacacia*) which is known as an especially aggressive invasive species [29]. Most of the feral maize plant individuals were observed in the warmer Pannonian region. Most records were from Burgenland and Styria, although density of sampling sites was much higher in Lower and Upper Austria, i.e. record density is not correlated with sampling density. Feral plants have further been found at the port of Enns where loading of maize seeds is regularly performed (Fig. 1n–p). Single-maize kernels are handled there and loaded on ships for further transportation. After loading, the storage areas of maize kernels are cleaned with brushes. If single-maize kernels remain in that area in spite of cleaning, they have the potential to germinate and develop a fertile plant.

Commercial maize has lost its ability to release single kernels from the cob. Hence, single-maize kernels are rare in fields and spillage of them probably mainly traces back to seeding and harvest activities of farmers. Additional factors such as storm damage, poor stalk quality, insect damage and plant diseases can lead to kernel and

ear losses which might result in volunteer maize in the following year [16]. Maize kernels are used as feed stuff for pigs, poultry or cattle fattening. Left overs reach the manure and in this way are dispersed into the environment during fertilisation. Feeding of game (e.g. wild boars) by hunters or fowl kept in an animal husbandry could be another source for the entry of single-maize kernels into semi-natural and natural habitats. For better feeding, the cobs are threshed into single components. This was probably also the case at the sampling site “Zitzmannsdorfer Wiesen”. No maize field was present in the surroundings of this ruderal habitat in the year of observation. Hence, it is likely that the feral plants originated from maize kernels used for game-feeding. Hunters sometimes cultivate fields for game browsing and protection against enemies. Single-maize plants are also part of this animal feed stuff. In a study in Korea [21], imported maize kernels were found to be usually processed and mixed with other components in the animal feed manufacturing plants, and finally consumed in the livestock barns.

Records of volunteer and feral maize plants in other countries

In a study conducted in Spain [3], the number of maize volunteers differed strongly between twelve tested fields ranging from low (30 plants/ha) to extremely high numbers (>8000 plants/ha), thus accounting for nearly 10% of the total plants in the field. This variability in numbers was caused by many factors such as climate conditions

in winter and early spring and applied agricultural practices (tillage, etc.). For instance, remnant maize kernels can suffer loss of vigour due to unfavourable weather in winter, may be at different depths in the ground and frequently lack optimal conditions for germination. It was observed that dry conditions during autumn favoured overwintering of non-germinated seeds in the fields.

In Spain, most of the volunteers generally did not produce any cob. If they did, the cobs were small and poorly pollinated. In contrast, most of the volunteers as well as several of the feral plants in the Austrian observations developed normal inflorescences and cobs with regularly developed kernels. They had normal vigour. Moreover, the plants did not show infestation but had a healthy appearance. The occurrence of these plants during several field study years does not mandatorily correspond to exceptional years with milder winter temperatures in Austria (www.zamg.ac.at, accessed 24th of July 2016).

Maize is commonly handled and transported as kernels threshed from the cob. Feral maize plants are able to develop from spillage events in course of seed loading in ports (Fig. 1n–p). The occurrence of feral GM maize as a result of kernel spillage during import, transport, storage, handling and processing activities was also confirmed for Korea, a country where no GM crop has recently been cultivated [21, 30, 31]. In the study of Kim et al. one GM maize plant was identified in a small vegetable garden in 2005 [30]. As a result of seed spillage, several GM maize plants were found along the roadside in the following year at a grain receiving port and around cultivated fields [31].

Moreover, several spilled maize kernels were observed around open storage areas of two ports and along truck transportation routes near feed manufacturing plants [21]. The monitoring sites focussed on retriever routes of imported maize from grain receiving ports to feed manufacturing plants and finally to livestock barns. While 120 kernels were found at or around the Incheon port—but no feral maize plants grew there—, 18 established feral maize individuals were registered at the Gunsan port. Fifteen of those were identified to have originated from GM varieties. Moreover, additional eight GM maize plants grew around four feed manufacturing plants and in two livestock barns. These findings prove that conventional as well as GM maize kernels are spilled during transportation and handling, and that both have the potential to develop fertile plants.

Maize has been cultivated in Europe for hundreds of years, but there is no indication so far that it has become an established weed even in countries with warmer climates despite genetic diversity of types and improvements. Although herbicide tolerance in maize, a selective advantage in habitats with herbicide application,

is already known to cause problems [16, 32–34], GM maize is still considered of limited concern in the context of invasive weeds, at least outside agricultural systems. However, this might change, if maize became better adapted to cold climatic conditions. Introduced artificial traits such as cold or frost tolerance could trigger a different behaviour of GM maize compared to its conventional counterparts. Several risk hypotheses for a transgene spread into non-agricultural habitats via feral and volunteer maize plants are already discussed [19]. Although experiments did not yet provide evidence for an increased risk of transgene spread via feral and volunteer maize, such rare events may still be evolutionarily significant and their frequency might have actually changed with climate change. Concerning the appearance of feral plants in Central Europe and the existence of hybridisation partners such as teosinte in Spain, the ecological risk of GM maize has obviously changed maybe due to warmer winters. Hence, a new risk assessment is urgently needed.

In contrast to oilseed rape—a crop originating from Central Europe—with very frequent occurrence of feral plants and volunteers in Austria [26, 35], maize also produces feral plants and volunteers in subsequent crops but with lower frequency. Because maize exhibits about 95% cross-fertilisation [21], it might cause a high out-crossing rate. Hence, it is realistic that GM contaminations descending from volunteer as well as from feral GM maize in organic and conventional maize fields have to be expected in a region where GM maize is cultivated or imported and will contribute to the total adventitious GM content in final products.

Conclusions

As a next clarifying step, it has to be investigated in detail if maize is also able to form self-sustaining populations outside cultivation and persist for subsequent years as a population. Although less probable in comparison to the crop oilseed rape, this essential aspect for transgene spread of GM maize has to be considered in ERA in future, especially in warmer areas such as the Pannonian region as shown here from observations in Austria. Additionally, detailed systematic and quantitative studies are needed to be able to verify if the maize plants persist over longer time periods or are transient. It is recommended that systematisation of research all over Europe should be performed in order to quantify the occurrence of feral and volunteer maize in regions with different winter temperatures.

Abbreviations

COGEM: Commission on Genetic Modification; EC: European Commission; EFSA: European Food Safety Authority; ERA: ecological risk assessment; EU:

European Union; GMO: genetically modified organism; GM: genetically modified; OECD: Organisation for Economic Cooperation and Development.

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Competing interests

The author declares that she has no competing interests.

Availability of data and materials

The data are exclusively based on photographs which are presented in the article.

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Spread of volunteer and feral maize plants in Central Europe: recent data from Austria

by Kathrin Pascher (University of Vienna)

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Background

Kathrin Pascher is a Vienna-based researcher who studies Austrian farmland biodiversity and other ecological issues. She teaches at the University of Vienna and the University of Natural Resources and Life Sciences (Boku).

On several occasions during her fieldwork on crops she found single maize plants, which were fully mature. She was surprised of her findings, since many scholars have denied that maize can grow outside of cultivation in our climate zone. She chose to publish her paper in a journal with open access to everyone so that the general public can read her findings as well. Another reason for choosing the *Environmental Sciences Europe* journal was that other journals which favor the introduction of genetically modified plants did not want to publish her findings. Even after this publication, the European Food Safety Authority reacted by downplaying her findings claiming that feral maize only grows weakly and cannot do any ecological harm. While Pascher did not intend to prove that genetically modified maize plants harm the Austrian environment, she points out that maize plants growing outside of cultivation exist and that the EFSA and other scholars should investigate possible effects.

Glossary

feral: the term “to become feral” in the context of a crop refers to the crop’s ability to occur outside cultivation

volunteer: a plant of a crop which survives and appears in the crop of the following year

crop: every plant grown by humans for food, renewable energy etc.

genetically modified organism (GMO): referring to an organism that has received genetic material from another organism through a laboratory procedure leading to a permanent change in one or more of its characteristics

transgenic plant: synonym for GMO; genetically engineered plants that contain useful genes from other species

herbicide tolerance: the ability of a plant not to react to chemicals that kill other plants that are undesired by the farmers

cross-pollination: the pollination of a flower with pollen from another plant of a closely related species in contrast to self-pollination in which pollen comes from the exact same plant

hybridisation: the production of one or more hybrid organisms by the mating of genetically different, but closely related parents.

non-agricultural habitats: an environment in which a specific organism lives which is not used as farmland

self-sustaining population: a group of individuals of the same species that is big enough to provide for their long-term persistence over multiple generations

anecdotal evidence: evidence collected in a casual or informal manner which relies heavily on personal observation

kernel: German: Korn

game: animals, such as deers, which are hunted for sport and food

oilseed rape: German: Raps

vigour: strength and energy

Abstract

Volunteer maize growing amongst next year's harvest might increase the risk of genetically modified maize contaminating non-genetically modified maize plants. The same re-evaluation of possible risks has to be done for genetically modified maize plants that can become feral. Scientists have confirmed that maize can become feral in European areas with Mediterranean climate such as Spain. However, in winter-cold areas with Central European continental climate like Austria maize volunteers and feral maize are extremely unlikely to be found outside of cultivation, according to many scientists. This paper presents field observations made over several years in many parts of Austria that confirm that volunteer and feral maize exists. They not only occur in several places not used for farming, they also seem to be fertile and fully developed. The different ways single maize kernels reach the soil are explained and need to be taken into account when assessing the ecological risks of volunteer and feral maize. While no genetically modified maize is grown in Austria, the results of this paper show that other countries with the same climate should consider that artificially introduced genes can enter natural habitats through GM maize. The European Food Safety Authority (EFSA) states that in principle maize has the potential to survive as a volunteer or feral plant also in regions with cold winters. Future research should investigate the frequency of volunteer and feral maize in other countries with Central European climate conditions and assess their potential for spreading transgenes.

Keywords: Maize, Corn, Genetically modified (GM), Feral plants, Volunteers, Central Europe, Transgene spread, Field observations, Ecological risk assessment (ERA), EU legislation

Introduction

Maize (*Zea mays* subsp. *mays*) is an annual crop frequently grown in many countries. This plant that only lives for one year can be modified through genetical engineering. Currently, around 30% of maize is genetically modified (GM)¹. In 2014, around 143 hectares of genetically modified maize were cultivated in the EU, mainly in Spain. Transgenic maize for commercial production, which means that the maize is produced to be sold for profit, confers either insect resistance or herbicide tolerance or a combination of both. People use maize mainly for food and livestock feed, but also for renewable resources. Maize has been subject to trait improvement via genetic modification for several decades. The main factors that determine the previously unexpected presence of a genetically modified organism (GMO) in non-GM material are unintended seed impurity, seed planting equipment and practices, cross-pollination between GM and non-GM crops, the presence of GM volunteers, and product mixing during harvest, transport and/or storage processes³. The presence of genetically modified material is sometimes due to farming activities, also sometimes the non-genetically modified plants use pollen of GM maize plants which leads to an implementation of transgenes in their descendants. Moreover, due to the breeders' current focus on improving and using only a few crop varieties, the diversity of locally cultivated maize varieties could be threatened in the future. Cross-pollination is possible in areas with hybridisation partners such as Mexico. A close relative of *Zea mays* called teosinte inhabits Mexico. However, teosinte has recently also been found in Spain where it behaves like an invasive weed of agricultural land, which means that this new plant harms the harvest by growing at unwanted places⁴.

Even though maize is a mainly wind-pollinated crop⁵, it has also been observed to function as pollen source for honey bees⁶. So, non-target organisms that collect pollen of maize plants, like bees, are exposed directly to GM pollen. Additionally, volunteer and feral maize plants contribute to a lengthened GM pollen exposure. Hence, the relevant environmental aspects of volunteer and feral maize include that genetically-modified plants disperse uncontrollably into the environment. This means that GM maize can spread, and nobody knows the consequences this could have. Another environmental aspect is the lengthened exposure of non-target organisms to GM pollen, and this pollen is then used, for example by bees for honey which people then eat. Additionally, the people growing the GM maize use more herbicides to remove volunteer and feral maize, which kills many other plants as well. And the last environmental consequence of the fact that maize can become feral or volunteer is that farmers have to revise the insect resistance management that is mandatory for GM crops.

European scientists and politicians are currently debating, whether maize volunteers in future crops may pose a problem also in the colder climatic zones of Europe. Moreover, it has been questioned, if maize even has the ability to become feral outside cultivation in areas with cold winter temperatures and how likely it is to become feral under Central European continental climate conditions compared to those in Mexico. Some scientists assume that maize, as a highly domesticated crop, has very little potential of invading new territory and poses a negligible ecological risk⁷. Maize seeds and seedlings are assumed to survive the winter only in southern European countries, such as Spain. There, maize kernels that remain on the soil after the harvest can germinate and develop into flowering individuals, which can locally cross-pollinate neighbouring maize plants⁸. However, by a combination of weak growth, different flowering times of the maize crop, low resistance to frost, low competitiveness, absence of an inactive period before germination, susceptibility to diseases, herbivory and cold climate conditions survival of the plants is estimated to be unlikely. This renders the risk of outcrossing and the establishment of a new population limited^{3,9,10}. So, while volunteer and feral maize seeds are known to be able to survive winter and grow in the following year in southern European countries, scientists claim that these newly grown plants are rarely able to reproduce and spread.

Studies from different central and northern European countries concerning this topic have also already been published. So far, there have been no records for survival of volunteer and feral maize plants in the Netherlands¹¹. Records for maize growing outside farm cultivations on the British Island have been made, but are rare^{12, 13}. Irish maize varieties, while cold adapted, were observed to still be frost intolerant¹⁴. However, single plants were registered in two Irish port locations, Limerick and Dublin¹⁵. In contrast, in an American study, several volunteer maize kernels were found to be winter-hard in northern latitudes and germinated the following spring¹⁶. Even in Germany, GM volunteer maize plants were recorded for the first time on a field owned by Monsanto in 2007. It is stated that climate change could be a driving force for overwintering of maize seeds in future¹⁷⁻¹⁹.

The invasiveness potential of a crop is the likelihood that it will persist and spread into non-agricultural habitats⁷. Ecological harm in connection with a GMO includes that the transgenic crop produces seeds, which then disperse to non-agricultural habitats, that the crop establishes in the non-agricultural habitat and forms a self-sustaining population. If feral plants spread and thereby influence the number of native species, they will cause ecological harm²⁰⁻²². It is often argued—because no visible ecological harm has been identified during the long history of cultivation of the conventional crop-type—that there would be no negative effect

originating from the GM crop. It is assumed that the chain of events listed above from cultivation to ecological harm is obviously broken at one or more links⁷, which means that either seeds cannot spread far enough or cannot reproduce efficiently to form a population which can survive on its own. An Irish Study¹⁴ summarizes the different views on GM maize:

“Evidence for this can be seen in the lack of anecdotal evidence supporting the existence of feral maize populations. It is safe to conclude therefore that under current climatic conditions and in the absence of selection pressure there is no likelihood of GMHT maize persisting over adjacent flora and hence there would be no detrimental impact on the Irish landscape should GMHT maize seed be lost pre-sowing”.

Also, the Organisation for Economic Cooperation and Development, OECD, is very skeptical towards a potential invasiveness of the crop maize²³:

“Volunteers are common in many agronomic systems, but they are easily controlled; however, maize is incapable of sustained reproduction outside of domestic cultivation”.

The Netherlands Commission on Genetic Modification, COGEM¹¹ also states:

“During its long domestication process, maize has lost its ability to survive in the wild. In the Netherlands, the appearance of maize volunteers is rare and establishment of volunteers in the wild has never been reported. There are no reasons to assume that the introduced trait will increase the potential of maize to establish feral populations. Contrastingly, other scientists consider maize becoming feral or volunteer as at least in principle possible”^{3, 24,25}.

Even the European Food Safety Authority (EFSA) gives the following statement concerning the occurrence of volunteer maize:

“Maize is highly domesticated and generally unable to survive in the environment without management intervention. Maize plants are not winter hardy in many regions of Europe; furthermore, they have lost their ability to release seeds from the cob and they do not occur outside cultivated land or disturbed habitats in agricultural landscapes of Europe, despite cultivation for many years. In cultivation, maize volunteers may arise under some environmental conditions (mild winters). Observations made on cobs, cob fragments or isolated grains shed in the field during harvesting, indicate that grains may survive and overwinter in some regions, resulting in volunteers in subsequent crops. The occurrence of maize volunteers has been reported in Spain and other European regions^{8,26}”.

Commercial maize has lost its ability to release single kernels from the cob. Hence, single-maize kernels are rare in fields and spilled kernels probably mainly trace back to being leftovers from the farmers’ seeding and harvesting. Additional factors such as storm damage, poor stem quality, insect damage and plant diseases can lead to kernel losses which might result in volunteer maize in the following year¹⁶. Maize kernels are used as feed stuff for pigs, poultry or for cattle fattening. Left overs can be found in animal dung which is then used as fertiliser and in this way the left overs are dispersed into the environment during fertilisation. Feeding of game (e.g. wild boars) by hunters or feeding of farm animals could be another source for the entry of single-maize kernels into natural habitats. For better feeding, the cobs are threshed into single components. Hunters sometimes cultivate fields to offer protection for

wild animals and food for these animals. Single-maize plants are also part of this animal feed stuff.

The present article will contribute to the debate on whether maize is able to become feral and to exist as a volunteer plant in Central Europe, exemplarily shown with Austrian data. Austria has a temperate Central European transition climate with a continental climate in the east of the country and influences of the oceanic climate in the West. Large climate differences exist between the moderate climate in the Alpine North and the Mediterranean influences in the Alpine South. Austria is rich in diversity of landscapes and of animal and plant species^{27,28}. In Austria, no farmer or scientist has ever released GM crops, neither for field experiments nor for cultivation. Several proofs (photographs taken during fieldwork) of the occurrence of volunteer and feral maize plants in Austria will be presented here.

Methods

All records reported here were made by accident during fieldwork for three studies in Austria. One of those three studies, the study BINATS²⁸ covered 100 test areas, each 625 × 625 m in size; 50 test areas were located in maize cultivation regions (Lower and Upper Austria, Burgenland, Styria, Carinthia) and 50 in oilseed rape cultivation regions (Lower and Upper Austria, Burgenland). For selection of test areas, a stratified random sampling procedure for monitoring biodiversity in the Austrian farming regions was applied. This procedure ensures that no specific criteria such as diversity of soil types, the distance between forests and the test area, how much soil is covered by grass, average annual temperature or average annual precipitation, effects the results. The second study, called FEAR²⁹, investigated the same 50 maize fields as the BINATS study, but also 50 potato fields. The third study³⁰ did not investigate fields, but presumable hotspots for spilling oilseed rape seeds such as switchyards (2), border railway stations (6), main ports (3), OSR importing oil mills (3) and an OSR processing facility (1) as well as randomly selected road sectors (2 kilometres; 22), railway stations (20) and small ports (3). As none of the sampling sites had been selected on expectations for the occurrence of volunteer and feral maize, the data presented here can be considered as anecdotal evidence for the existence of volunteer and feral maize under Central European conditions at several locations in Austria throughout several years. However, the data does not allow any assessment on regional distribution and abundance, which means that we do not know where and how much feral maize grows in Austria.

Results

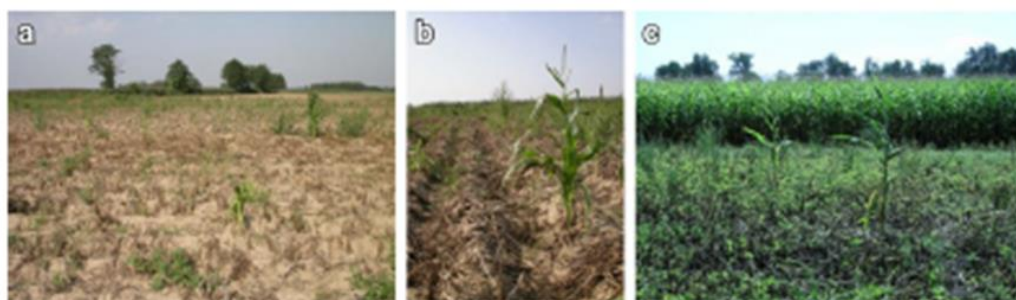




Fig. 1 Observations of volunteer (a–e) and feral (f–p) maize in Austria.

Volunteer maize:

a–c: potato fields near Bad Radkersburg in Styria (7th August 2011);

d: soybean field in Landegg close to Hornstein in Lower Austria (11th August 2011);

e: pumpkin field in Hausleiten in Lower Austria (9th September 2011).

Feral maize:

f: Hornstein, Burgenland (18th August 2007);

g: and h Purbach am Neusiedlersee, Burgenland (12th August 2008);

i–k: at the edge of the “Zitzmannsdorfer Wiesen”, Neusiedlersee, Burgenland (19th August 2010);

l and m: Nestelbach, Styria;

n and o: loading area in the port of Enns, Upper Austria (12th August 2015);

p: pile of sand located in the port of Enns, Upper Austria (12th August 2015), moreover feral oilseed rape plants can be observed on the pile.

Volunteer maize plants were observed in two potato fields in Styria as well as in a soybean and a pumpkin field in Lower Austria in the summer of 2011 (Figs. 1a–e, 2) during field

sampling²⁹. Several of the volunteer plant individuals found flowered and had already produced healthy cobs. Feral maize plants were observed in three Austrian Federal States (Burgenland, Styria and Upper Austria; Fig. 2) in August in the years 2007, 2008, 2010 and 2015 during fieldwork for three studies²⁸⁻³¹. Most of the feral plants were fertile and had already produced cobs. Particular emphasis has to be put on the observation of the highest number of observed feral maize plants on the edge of the “Zitzmannsdorfer Wiesen” as this area is part of the National Park Neusiedler See—Seewinkel. As mentioned in the introduction, game-feeding is a factor which can result in an occurrence of maize plants. Game feeding is a common practice in national parks and since no maize field was present in the surroundings of this habitat in the year of observation, it is likely that the feral plants originated from maize kernels used for game-feeding.

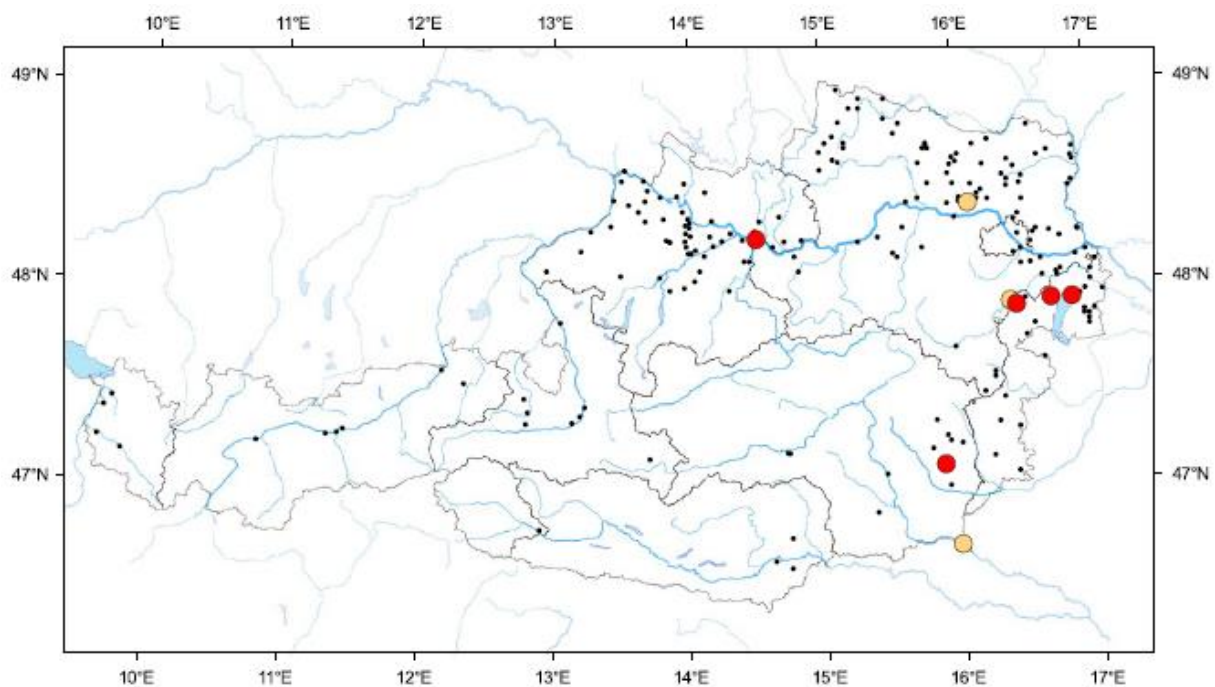


Fig. 2 Austrian map with spots of discovery of volunteer and feral plants.

The locations of altogether 210 test areas/ sampling sites of three Austrian studies (BINATS²⁸, FEAR²⁹, study dealing with imported oilseed rape³⁰) are indicated in the map with small black dots.

Volunteer maize (marked with light-orange spots): Radkersburg in Styria, Landegg bei Hornstein in Lower Austria, Hausleiten in Lower Austria. Feral maize (marked with red spots): Hornstein in Burgenland, Purbach in Burgenland, “Zitzmannsdorfer Wiesen” in Burgenland, Nestelbach in Styria, port of Enns in Upper Austria.

Discussion

The study conducted in Spain³, which showed the presence of volunteer maize in this southern country also showed that the number of maize volunteers differed strongly between twelve tested fields; ranging from low (30 plants/ha) to extremely high numbers (>8000 plants/ha). This variability in numbers was caused by many factors such as climate conditions in winter and early spring and applied agricultural practices (soil modification, etc.). For

instance, remaining maize kernels can suffer loss of vigour due to unfavourable weather in the winter. Consequently, the kernels may be at different depths in the ground and frequently lack optimal conditions for germination. It was observed that dry conditions during autumn benefited the overwintering of non-germinated seeds in the fields.

In Spain, most of the volunteers generally did not produce any cob. If they did, the cobs were small and poorly pollinated. In contrast, most of the volunteers as well as several of the feral plants in the Austrian observations developed normal flowers and cobs with regularly developed kernels. They had normal vigour. Moreover, the plants did not show threatening infections but appeared to be healthy.

Feral GM maize occurs probably as a result of people spilling kernels during import, transport, storage, handling and processing activities was also confirmed for Korea, a country where no GM crop has recently been cultivated^{24,32,33}. In the study of Kim et al.²⁴ one GM maize plant was identified in a small vegetable garden in 2005³². As a result of seed spillage, several GM maize plants were found along the roadside in the following year at a grain receiving port and around cultivated fields³³. Moreover, several spilled maize kernels were observed around open storage areas of two ports and along truck transportation routes near feed manufacturing plants. The findings of this Korean study prove that conventional as well as GM maize kernels are spilled during transportation and handling, and that both have the potential to develop fertile plants which supports the findings of this study.

Maize has been cultivated in Europe for hundreds of years, but there is no indication so far that it has become an established weed even in countries with warmer climates despite genetic diversity of types and improvements. Although herbicide tolerance in maize, a selective advantage in habitats where herbicides are applied, is already known to cause problems^{16, 34-36}, GM maize is still considered of limited concern in the context of invasive weeds, at least outside agricultural systems. However, this might change, if maize became better adapted to cold climatic conditions. Introduced artificial traits such as cold or frost tolerance could trigger a different behaviour of GM maize compared to its conventional counterparts. The risks of transgenes spreading into non-agricultural habitats via feral and volunteer maize plants are already discussed²². Although experiments did not yet provide evidence for an increased risk of transgene spread via feral and volunteer maize, such rare events may still be evolutionarily significant, and their frequency might have actually changed with climate change. Concerning feral plants that appear in Central Europe and the existence of hybridisation partners such as teosinte in Spain, the ecological risk of GM maize has changed, maybe due to warmer winters. Hence, a new risk assessment is urgently needed. In contrast to oilseed rape—a crop originating from Central Europe—with very frequent occurrence of feral plants and volunteers in Austria^{29,37}, maize also produces feral plants and volunteers in subsequent crops but with lower frequency. Because 95% of maize reproduce with different individuals and not with themselves²⁴, it might be probable that genetic material also enters the genetics of different breeds. Hence, it is realistic that GM contaminations descending from volunteer as well as from feral GM maize in organic and conventional maize fields have to be expected in a region where GM maize is cultivated or imported and this will contribute to the total accidental GM content in final products.

Conclusion

As a next clarifying step, scholars should investigate in detail if maize is also able to form self-sustaining populations outside cultivation and persist for several following years as a population. Although the transgene spread through oilseed rape is potentially more, the transgene spread of GM maize has to be considered in ecological risk assessment in future as well. Considering the possibility of genetically modified maize spreading in an uncontrollable way is especially important for warmer areas such as the Pannonian region, which follows from the observations in Austria presented in this paper. In addition to the anecdotal evidence presented here, detailed systematic and quantitative studies are needed to be able to verify if the maize plants are able to live over longer time periods or are not durable. Systematisation of research all over Europe should be performed in order to quantify the occurrence of feral and volunteer maize in regions with different winter temperatures.

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Competing interests

The author declares that she has no competing interests.

Availability of data and materials

The data are exclusively based on photographs which are presented in the article.

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Reading Comprehension Test

Read the text carefully and then circle the right answer:

- (1) Which statement best describes the conclusion section?
- Implications for the future
 - The difference to oilseed rape
 - Impact on the environment
 - Harder winters
- (2) Some scientists say that maize cannot flourish outside of cultivation in Austria and other Central European countries, because ...
- of the hot summers
 - of the large amount of rain
 - of the cold winters
 - of the soil
- (3) What can **not** be inferred from the abstract?
- used methods
 - the general findings
 - future implications
 - current position of the organization concerned with the issue
- (4) Which method was used in the paper?
- Genetic marker analysis
 - Systematic satellite observation
 - Observation during other field studies
 - Soil examination
- (5) According to the introduction, researchers ...
- are certain that GM maize cannot do any ecological harm
 - are divided if GM maize might harm its environment
 - believe that GM maize destroys whole ecosystems in Europe
 - have not discussed the topic of GM maize until now
- (6) Maize (*Zea mays*) is primarily ...
- wind-pollinated
 - insect-pollinated
 - water-pollinated
 - bird-pollinated
- (7) Pascher reveals in her paper that ...
- genetically modified maize plants harm the environment in Austria
 - Zea mays* behaves like an invasive weed in Austria and increases ecological risk

- iii. through her risk assessment we now know that GM maize is dangerous for the environment
 - iv. *Zea mays* can survive winters in Austria and grow at locations where it was not planted
- (8) How do the results of this paper differ from the previous opinion of the EFSA?
- i. The EFSA's studies conducted previous to Pascher (2016) showed the same results as Pascher (2016)
 - ii. Pascher proved the occurrence of volunteer and feral maize plants in Austria for the first time
 - iii. Pascher found fully developed and healthy volunteer and feral maize plants
 - iv. The EFSA discovered fully grown and mature maize plants in contrast to Pascher (2016)
- (9) How could one decrease the amount of feral maize at the "Zitzmannsdorfer Wiese" most effectively?
- i. stop planting maize on nearby fields
 - ii. stop spreading maize kernels for feeding wild animals
 - iii. close the maize processing manufactory next to the field
 - iv. pay more attention to kernels that fall on the ground during transportation
- (10) How many study sites were observed for Pascher's paper (2016) in total?
- i. 150
 - ii. 100
 - iii. 210
 - iv. 260
- (11) Which possible next step can **not** be inferred from the conclusion?
- i. the inclusion of GM maize into ecological risk assessment
 - ii. more quantitative studies on the same issue
 - iii. more studies in warmer Central European regions
 - iv. changes concerning the authorization of GM maize
- (12) What is the main ecological risk of planting GMOs?
- i. New traits, such as herbicide tolerance, can spread to non-GM plants which can then invade new niches
 - ii. The transgenes can spread into the drinking water and will contaminate it for animals and humans
 - iii. The genetically modified plants can corrupt our DNA if we eat the products based on GMOs
 - iv. The newly introduced genes can alter the soil to such an extent that no other plants can grow there anymore

Wissenschaftliche Artikel lesen

Fragebogen A

Der Fragebogen dient zum besseren Interpretieren der Daten des Lesekompetenztests. Die Daten werden in einer Diplomarbeit auf der Universität Wien anonym veröffentlicht. Es gibt bei diesem Fragebogen keine richtigen oder falschen Antworten, jedoch bitte ich dich darum deine Antworten sorgfältig und ehrlich zu beantworten. Die Antworten sind entweder zu schreiben oder eine Antwortmöglichkeit einzuringeln.

Klasse: _____ **Alter:** _____ **Geschlecht:** weiblich: ____ männlich: ____

Was ist/sind deine Muttersprache/n? _____

Wie gut bist du im Lesen von englischen Texten? Beurteile deine Lesekompetenz anhand von Schulnoten:

1 2 3 4 5

Hast du für deine VWA wissenschaftliche Texte gelesen, wenn ja, wie viele?

Nein 1-5 5-10 10-15 15+

Hast du für deine VWA englischsprachige wissenschaftliche Texte gelesen, wenn ja, wie viele?

Nein 1-5 5-10 10-15 15+

Wie lautet das Thema deiner VWA?

In welcher Sprache hast du deine VWA verfasst? _____

Welche Noten hattest du im letzten Zeugnis in den folgenden Gegenständen?

Englisch: 1 2 3 4 5 Biologie: 1 2 3 4 5

Wie viel Vorwissen hattest du zu dem Thema des Artikels (Genmodifizierte Pflanzen)?

Keines Ein wenig Mittelmäßig viel Viel Sehr viel

Wie viel Vorwissen hattest schon vorher über Biotechnologie und Landwirtschaft?

Keines Ein wenig Mittelmäßig viel Viel Sehr viel

Hast du nach dem Lesen des Artikels ein besseres Verständnis für den Beruf eines/r Biologen/in?

Nein Ein wenig Mittelmäßig besser Besser Sehr viel besser

Hat dich der Artikel motiviert mehr über das Thema oder die Biologie als Wissenschaft zu lernen?

Nein Ein wenig Mittelmäßig viel Viel Sehr viel

Wie viel Prozent des gerade gelesenen Textes, glaubst du, hast du verstanden:

a. 0% b. 20% c. 40% d. 60% e. 80% f. 100%

Was war für dich schwierig zu verstehen?

Sonstige Anmerkungen:

Danke für deine Mitarbeit!

Wissenschaftliche Artikel lesen

Fragebogen B

Der Fragebogen dient zum besseren Interpretieren der Daten des Lesekompetenztests. Die Daten werden in einer Diplomarbeit auf der Universität Wien anonym veröffentlicht. Es gibt bei diesem Fragebogen keine richtigen oder falschen Antworten, jedoch bitte ich dich darum deine Antworten sorgfältig und ehrlich zu beantworten. Die Antworten sind entweder zu schreiben oder eine Antwortmöglichkeit ist einzuringeln.

Klasse: _____ **Alter:** _____ **Geschlecht:** weiblich: ____ männlich: ____

Was ist/sind deine Muttersprache/n? _____

Wie gut bist du im Lesen von englischen Texten? Beurteile deine Lesekompetenz anhand von Schulnoten:

1 2 3 4 5

Hast du für deine VWA wissenschaftliche Texte gelesen, wenn ja, wie viele?

Nein 1-5 5-10 10-15 15+

Hast du für deine VWA englischsprachige wissenschaftliche Texte gelesen, wenn ja, wie viele?

Nein 1-5 5-10 10-15 15+

Wie lautet das Thema deiner VWA?

In welcher Sprache hast du deine VWA verfasst? _____

Welche Noten hattest du im letzten Zeugnis in den folgenden Gegenständen?

Englisch: 1 2 3 4 5 Biologie: 1 2 3 4 5

Wie viel Vorwissen hattest du zu dem Thema des Artikels (Genmodifizierte Pflanzen)?

Keines Ein wenig Mittelmäßig viel Viel Sehr viel

Wie viel Vorwissen hattest schon vorher über Biotechnologie und Landwirtschaft?

Keines Ein wenig Mittelmäßig viel Viel Sehr viel

Hast du nach dem Lesen des Artikels ein besseres Verständnis für den Beruf eines/r Biologen/in?

Nein Ein wenig Mittelmäßig besser Besser Sehr viel besser

Hat dich der Artikel motiviert mehr über das Thema oder die Biologie als Wissenschaft zu lernen?

Nein Ein wenig Mittelmäßig viel Viel Sehr viel

Wie viel Prozent des gerade gelesenen Textes, glaubst du, hast du verstanden:

a. 0% b. 20% c. 40% d. 60% e. 80% f. 100%

Was war für dich schwierig zu verstehen?

Hat dir die Background-Box geholfen den Text und die Kommunikation zwischen Wissenschaftlern besser zu verstehen? Wenn ja, wie?

Danke für deine Mitarbeit!

Zusammenfassung

Diese Diplomarbeit behandelt das Thema der Adaptierung von naturwissenschaftlichen Forschungsartikel für den Biologie und Umweltkunde Unterricht in der Sekundarstufe. Durch das Zusammenführen zweier Adaptierungsmethoden und der Anpassung dieser an die Ziele von Content-and-Language-Integrated-Learning im österreichischen Kontext wurde ein Leitfaden zur Vereinfachung naturwissenschaftlicher Texte erstellt. Eine der Theorien entstammt der Fachdidaktik der Naturwissenschaften, nämlich das Konzept der ‚Adapted Primary Literature‘, und diese wird kombiniert mit der sprachwissenschaftlichen Herangehensweise der Textvereinfachung. Der entstandene Leitfaden wurde an einem Text (Pascher 2016) angewandt, welcher wiederum in einer empirischen Studie zum Einsatz kam. Diese Studie wurde mit TeilnehmerInnen, welche im zwölften Schuljahr CLIL-Unterricht besuchen; durchgeführt. Die SchülerInnen wurden in zwei Gruppen geteilt, wobei eine Gruppe den originalen Forschungsartikel lesen sollte und die andere Gruppe den vom Autor vereinfachten Forschungsartikel. Durch einen Lesekompetenz-Test und einem Fragebogen wurden mögliche Unterschiede erforscht. Durch die kleine Anzahl an TeilnehmerInnen sind die Ergebnisse der quantitativen Analyse nicht vollkommen eindeutig, jedoch kann man aus der qualitativen Analyse der Fragebögen herauslesen, dass ein Einsatz von adaptierten Forschungsartikeln positiv zu bewerten ist.

Abstract

The diploma thesis at hand is concerned with the topic of adapting scientific texts for the biology classroom in secondary school. This study sets out to combine the research field around Adapted Primary Literature, which originated within science education, and the field of linguistic modification and connect the suggestions put forward by the literature with the demands of a quality CLIL classroom in an Austrian setting. Through connecting the approaches of science education and language learning, especially reading, a new adaptation framework has been created, tailored to the Austrian CLIL classroom. The adaptation guideline is consequently applied to Pascher (2016) and the differences in reading comprehension are studied in the empirical part. The participants consist of two groups, one read the original Primary Scientific Literature text and the other group received the Hybrid Adapted Primary Literature text, adapted after the guideline of the theoretical part of this thesis. The data collected consists of a reading comprehension test and questionnaires concerning the different topics mentioned in the theoretical part. While the limitations of the small-scale reading comprehension test led to rather weak results, the qualitative analysis and the literature researched both support the use of Adapted Primary Literature in the Austrian CLIL biology classroom.