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The possibilities of the Zahlenbuch 4 in the development of students' communication skills

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Introduction

Globalisation and the rapid technological advancements, among others, have led to a world that is increasingly more volatile and in which the future is becoming hard to predict (Fadel et al., 2015). These new developments bring many opportunities with them, for instance the creation of new jobs or international communication. On the other hand, they also bring about new, unknown challenges that children who are now in school will need to deal with throughout their lives, such as political unrest or natural catastrophes and the reduction of jobs due to mass production or AI (Scott, 2015).

However, several studies have claimed that education has been slow to adapt. Learners will need to acquire new skill sets in order to be successful in this rapidly changing world. Hence, in recent years, there has been significant attention given to educational reforms, the adaptation of curricula and the improvement of learning experiences (OECD, 2019; Solórzano et al., 2018; UNESCO, 2016; Fadel et al., 2015;). Amadio et al. (2014) have emphasised that the traditional conception of educational institutions as transmitters of knowledge is not sufficient anymore. Additionally, students should be acquiring 21st century skills, such as problem-solving, ICT literacy, critical thinking, adaptability, and communication and collaboration skills (UNESCO, 2016; Scott, 2015). Various organisations and studies have suggested different comprehensive overviews of which skills learners should attain. While some terms may vary, there seems to be a common consensus about certain skills that are more commonly put forward. Among those heavily emphasised are students' communication skills.

Communication is concerned with conveying information and expressing one's ideas or feelings through the use of words and sounds or in non-verbal ways (Merriam-Webster, 2022). It is an important skill for students to acquire in order to build successful relationships and avoid misunderstandings (Scott, 2014).

Solórzano et al. (2018) emphasise that the development of skills in children should be supported from as early as possible across all subjects. Various factors play a role in students'

acquisition of skills. Amadio et al. (2014) point out that the “structure of the curriculum, organisation of learning experiences, teaching methods and assessment systems” (p. 2) must be reviewed to promote effective development.

Learning experiences are not only shaped by the curriculum, the immediate environment or the teacher but also by the textbook. Textbooks are crucial factors in the implementation of the intended curriculum in various educational environments (Valverde et al., 2002). Sievert et al. (2019) state that “textbooks translate the abstract curriculum into concrete operations teachers and students can carry out” (p. 3). Textbooks tend to be used in class daily and in many schools, they form the basis of the teaching and learning process, providing teachers with an orientation for their teaching. As part of the TIMSS study, Mullis et al. (2012) describe the use of textbooks in the classroom and found that the mathematics textbook is the most important learning resource for teachers’ classroom instruction.

According to Fadel, “education can be a powerful tool for survival, but the competencies to meet these challenges are currently not being taught consistently and effectively” (p. 8). Given their relevance in informing teaching and implementing the curriculum, it is important to gain further insights into how textbooks can support the successful implementation of the curriculum and the acquisition of communication and collaboration skills.

The author of this thesis first became interested in the study of textbooks after an assignment as part of the Master’s education. When analysing old mathematics textbooks, it became apparent that there was hardly any space for skill development, especially with regards to communication and collaboration. Given Germany’s curriculum reforms, the question arose, whether textbooks have been sufficiently adapted. As a teacher of mathematics, the author is furthermore interested to see how a variety of textbooks deal with the demands of 21st century education and what recommendations can be given when working with certain textbooks. It appears that textbook research with regards to skill development is still scarce despite their important role in the classroom.

One of the most commonly used primary mathematics textbooks, that the researcher already used themselves as a student, is the 'Zahlenbuch' which was voted the mathematics textbook of the year in 2017 (*Sieger beim Schulbuch*, 2017). Therefore, it was chosen as the object of analysis for this study. Within the research, the book will be referred to either as *Zahlenbuch* or in specific as *Zahlenbuch 4*.

Wittmann, E. C., Müller, G. N., Nührenbörger, M., Schwarzkopf, R. (2017). *Das Zahlenbuch 4*. Stuttgart. Ernst Klett Verlag.

Hence, the **object of this research** is the possibilities of the mathematics textbook Zahlenbuch 4 in supporting the development of students' communication skills.

The **relevance** of this thesis is that it will provide data in a field where, currently, little research is available.

Aim and Research Questions

The **main aim of the research** is to investigate the possibilities of the mathematics textbook Zahlenbuch 4 in supporting students' development of communication skills and to provide recommendations for teachers on how to effectively use the textbook. To reach the aim, the following research question will be addressed:

What are the possibilities of the Zahlenbuch 4 in developing students' communication skills?

In order to answer the research question, several sub-questions have been formulated.

1. What are communication skills and how can they be developed in school?
2. What is the role of textbooks in (primary) education?
3. How does the content of the Zahlenbuch 4 support the development of communication skills?

4. What are teachers' views on the Zahlenbuch 4?

Tasks and Stages of the Thesis

To meet the objectives and answer the research questions, several tasks will be completed:

1. Analysis of theoretical literature: relevant literature will be selected and analysed and connections between sources will be made
2. Development and justification of research design and methodology
3. Analysis of the primary school mathematics textbook 'Zahlenbuch 4'
4. Development of interview questions and selection of an appropriate sample of participants
5. Collection and analysis of data
6. Presentation of results, conclusions and recommendations

Research Methods

The research methods include a literature review, textbook analysis, and semi-structured interviews.

Research Bases

The selected mathematics textbook is the Zahlenbuch 4 of North Rhine-Westphalia. As part of the study, 5 German primary school teachers were supposed to be interviewed, due to deviations only 3 were interviewed.

Structure of the Work

The first four chapters provide the main theoretical foundation for the study. Within the first chapter a general outline of education and skills for the 21st century is given. Chapter two focuses on skills within the state curriculum of North Rhine-Westphalia (NRW) with a special

emphasis on communication. The third chapter examines communication skills within the context of education and mathematics and how they can be developed. The fourth chapter outlines the general role of the textbook in planning, implementing the curriculum and development of knowledge and skills.

The next three chapters focus on the practical part of the study. Chapter five provides an outline and justification of the research design. Chapter six presents the results of the textbook analysis, while chapter 7 presents the interviews results.

Finally, Chapter eight provides conclusions to the study as well as limitations and recommendations for further research and chapter 9 lists the references of the study.

The Master Thesis contains blub pages, blub tables, blub figures, blub sources, and bluib appendices.

Theoretical Framework

1 Skills in the frame of 21st Century Curricula

"Curriculum is the vehicle through which a country empowers its citizens with the necessary knowledge, skills, attitudes and values that make them to be empowered for personal and national development" (Kabita & Ji, 2017, as cited in Ndihokubwayo & Habiyaremye, 2018, p. 40). Due to globalisation, the world we live in is becoming progressively more volatile and unexpected challenges arise which are not likely to pass by themselves (Cheng, 2014; Scott, 2015). Cheng (2014) and Scott (2015) mention mass production, migration, less predictable environments and catastrophes, political unrest and new technologies among the challenges that now young learners will have to deal with. Hence, the purpose of education should be to prepare students for the world of the future and to encourage them to improve it (Fadel et al., 2015). As Solórzano et al. (2018) point out, education should now aim to form "integral people for an increasingly complex society, where technical skills and abilities are developed equally" (p. 1).

However, it is often argued that education has been too slow to adapt to these new changes. Fadel et al. (2015) also point out that many education systems still fail to prepare learners for the future and advocate for a redesign of our approach to education for the development of skills that will set learners up for success. Amadio et al. (2014) argue that in many places the curriculum still tends to be more concentrated on "traditional conceptions of learning and teaching" (p. 2) and changes are needed to better prepare learners for the future. Likewise, in 2018, the OECD published their "Education 2030" paper in which they address the need to adapt education to better fit the challenges of our rapidly changing world.

In 2015, the 2030 Agenda for sustainable development, which includes 17 Sustainable Development Goals (SDG), was adopted by all members of the United Nations. SDG 4 has quality education for all at its core. According to UNESCO (2016), "quality education necessitates,

at a minimum, that learners develop foundational literacy and numeracy skills as building blocks for further learning, as well as higher-order skills" (p.30). They state that a focus purely on work-specific skills is not sufficient as graduates will lack the necessary skills to adapt to their ever-changing environments.

While there may be differences across studies, a consensus view seems to be that school curricula should shift their focus towards the development of certain transferable skills (Scott, 2015: Fadel et al., 2015; Amadio et al., 2014; OECD, 2019). In 2001, German students scored significantly below average in all categories of the PISA studies causing strong reactions from both politicians and media (Gundlach, 2003). This so-called "PISA Schock" played a crucial role in governmental decisions, both on regional and national levels in revising the curriculum and ensuring high quality education for all.

1.1 Skills for the Future

According to the OECD (2019), "skills are the ability and capacity to carry out processes and be able to use one's knowledge in a responsible way to achieve a goal" (p. 4). Different terms have emerged, to characterise the skills that learners need, such as 21st century skills, soft skills, cross-curricular competencies, deeper learning outcome or higher- order thinking skills. While there may be slight differences in definitions, the overall idea of these terms remains the same. Hence, within this study the terms *21st century skills* or *skills* will be used.

Many organisations and researchers have published frameworks of those skills which they believe will be most essential for students.

Within their Learning Compass 2030, the OECD (2019) categorises different types of skills:

- cognitive and metacognitive skills; these include critical and creative thinking, learning to learn and self-regulation;
- social and emotional skills; these include empathy, self-efficacy, responsibility and collaboration; and
- physical and practical skills; including the use of ICT devices.

It is important to note, “that knowledge, skills, and attitudes and values are not competing competencies but rather are developed interdependently” (OECD, 2019, p.5).

UNESCO (2016) argues that students need to build a repertoire of skills that are not limited to certain work-specific fields but provide a broader range of application opportunities. Furthermore, students need to receive opportunities to continuously develop their skills throughout life. These high-level transferable skills according to UNESCO (2016) include:

- problem-solving, critical thinking and creativity; and
- teamwork, communication skills and conflict resolution.

Chalkiadaki (2018), conducted a systematic literature review of 40 texts, examining 21st century skills in primary education. She organised the most prevalent skills within three categories:

- personal skills: creativity, problem-solving, and adaptability;
- social skills: communication skills (often together with collaboration) and global awareness; and
- digital literacy.

Scott (2015) also provides an overview of skills that are outlined across literature. She highlights that many 21st century skills are not new, they simply became “newly important” (p.2):

- A division can be made into personal skills, like initiative or creativity, social skills, like teamwork and compassion, and learning skills, like organising and meta-cognitive skills.
- Wagner (2010 as cited in Scott, 2015, p.3) lists seven survival skills: critical thinking and problem solving, collaboration and leadership, agility and adaptability, initiative and entrepreneurialism, effective oral and written communication, accessing and analysing information, curiosity and imagination.

Fadel et al. (2015) provide a ‘21st century competencies framework’ in which they describe competencies that students will need in the 21st century across different dimensions. Within the skills dimension, they outline the 4Cs:

- creativity;
- critical thinking;
- communication; and
- collaboration.

Another commonly used framework is the ‘Framework for 21st century learning’ by Partnership for 21st Century Learning (P21). P21 (2019) aims to provide a foundation for the implementation of “a blend of knowledge, specific skills, expertise and literacies” (p. 2). Similar to Fadel et al. (2015), they outline the interconnectedness of different areas of learning, with key subjects and 21st century themes at their core, and life and career skills, learning and innovation skills and information, media, and technology skills as interconnected components. They argue that learning and innovation skills currently play the most crucial factor in preparing students for the future. Again, their distinction of skills is in line with Fadel et al.’s (2015) work in the skills dimension, as P21 (2019) focuses on the 4Cs:

- creativity and innovation;
- critical thinking and problem-solving; and
- communication and collaboration.

1.2 Summary and Conclusion of the Chapter

Overall it can be said that skills have become a highly valued part of education. They have received attention from both international organisations as well as national researchers.

It becomes apparent that there are several common threads among the frameworks proposed by the organisations. Cognitive skills, such as creativity, critical thinking and problem-solving appear in the majority of sources and the authors agree that these are crucial skills for

learners to acquire in the 21st century. Additionally, social skills like teamwork, conflict resolution, communication and collaboration skills are highlighted by all authors.

While there are differences between the frameworks and descriptions of skills, the 4C approach is taken up by several authors and organisations. Both, Fadel et al. (2015) and P21 (2019) claim critical thinking, creativity, communication and collaboration to be the most important skills for students to develop. This study will reflect this view by focusing on one of these important skills, communication.

Skill Development has also become a recognized issue in German education. The first changes were made to the curriculum in 2008, when Germany moved to a competence-based curriculum. The upcoming sections will give an outline of the state curriculum of North Rhine Westphalia with special attention given to the subject of mathematics and the development of communications skills.

2 Skills within the NRW curriculum

2.1 General Information

Germany does not have a centralised education system. While the structure of kindergarten, primary school and high school exists and all students have the opportunity to leave high school with the same final diploma (Abitur), the federal government has little influence on educational topics as the responsibility for each education system lies with the respective state. Primary Education in NRW, as in most of Germany, lasts for 4 years. Students enter school at the age of 6 and move on to different types of high school after Grade 4.

The presented study is conducted in a city in North Rhine-Westphalia, the biggest and most densely populated state, located in north-western Germany. Due to the shift to competency-based education, instead of compulsory lesson content, the curriculum now describes com-

petences that are expected from students at the end of year 2 and year 4 to support independent and individual learning (Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen, 2008).

The curriculum is openly accessible on the website of the ministry of education where several documents describe the competency-based curriculum of NRW. They outline the general guidelines in addition to the specific competencies that are to be attained in each subject in two stages of children's primary school time. In 2021, revisions were published, with adaptations being made to all subject-specific curricula. The general guidelines document of 2008 remained the same. Due to the pandemic situation and the pressure on schools, it has been decided that these changes come into effect during the school year of 2021/22 but will not gain validity until the next school year of 2022/23 (Qua-lis NRW, 2021).

2.2 Aims of the curriculum

The curricula contain binding requirements for the learning and teaching processes in primary schools and are supplemented with pedagogical guidelines and task areas. According to the Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen (2008), the role of the school is to convey knowledge, skills, abilities and values while respecting the individual differences of students. It should support the development of personality and independence in decisions and actions as well as the feeling of responsibility in various areas of life. Several specific aims are described stating that students should learn (Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen, 2008, p. 11):

- to act independently;
- to learn for themselves and with others;
- to express their own opinion and respect that of others;
- to make personal decisions with regards to religious questions and to develop understanding and tolerance towards the decision of others;

- to understand the basic norms of the constitution and to stand up for democracy;
- to develop skills of perception and expression along with artistic skills;
- to develop enjoyment of movement and to live healthily; and
- to deal with media consciously and responsibly.

2.3 General Competencies

According to the Ministerium für Schule und Weiterbildung des Landes Nordrhein-Westfalen (2008), certain general competencies are crucial for students to apply new knowledge and skills. The ministry describes four interdisciplinary competencies:

Perceiving and communicating (wahrnehmen und kommunizieren) concerns directed attention. Students should learn to share personal observations and assessments with others in different, appropriate ways and to evaluate their own perceptions in conversation.

Within the competence for **analysing and reflecting** (analysieren und reflektieren) students learn to compare new insights with existing knowledge and patterns. Problems and tasks should be examined in a goal-oriented and systematic way by using previous knowledge, assumptions and comparisons as well as subject related and interdisciplinary procedures.

Structuring and representing (strukturieren und darstellen) refers to the competency of students to formulate and capture insights and results. Models and concepts show whether students have understood what they learned.

Transferring and applying (transferieren und anwenden) concerns the competency of students to use their knowledge and skills in new situations. Students learn to evaluate whether solutions and procedures are applicable in different contexts and for different problems.

2.4 The NRW Mathematics Curriculum

Mathematics within the NRW curriculum should be understood as a “constructive and discovering process” (Ministerium für Schule und Bildung, 2021, p. 73). Students should acquire knowledge, skills, abilities and values.

While there is a distinction between process related skills and content related skills, the authors highlight that these are inextricably interconnected. Competencies or skills will be acquired or developed through interaction with concrete learning experiences (Ministerium für Schule und Bildung, 2021).

The mathematics curriculum outlines five process related competencies (Ministerium für Schule und Bildung, 2021):

1. Problem solving: exploring, solving and reflecting.
2. Modelling: structuring, mathematising and interpreting.
3. Communicating: describing, documenting and cooperating.
4. Arguing: presuming, justifying, verifying.
5. Representing: Understanding, using, linking.

As this research focuses on communication skills, the third category is the most important to consider. According to the curriculum, communication is about representing and exchanging thought processes in an appropriate and understandable way. Students may initially communicate using everyday language but should later move on to more focused terminology.

Students’ primary school years are separated into two parts. The ‘school entrance phase’ (Schuleingangsphase) encompasses Year 1 and 2 but may take between one or three years depending on a child’s development. The curriculum describes the skills that students should develop by the end of the school entrance phase as well as skills to be attained by the end of

primary school. This study concentrates on textbooks of Year 3 and 4. The following expectations regarding communication skills are set for students to be reached at the end of primary school in year 4 (Ministerium für Schule und Bildung, 2021):

- Describe relations and rules based on examples.
- Explain their own methods and ideas.
- Name and use criteria of good descriptions.
- Record their results, methods and learning experiences.
- Use appropriate forms of representation to present ways of solutions, ideas or results.
- Use appropriate terminology and mathematical notations.
- Represent ways of solutions, ideas or results in a way that is understandable for peers (for instance during 'Math conferences').
- Collaboratively work on tasks and follow rules and agreements.
- Put their own and other's viewpoints into relation.

2.5 Summary and Conclusion of the Chapter

Everything considered, it can be said that skill development plays an important role in the German curriculum. There are standards on content that should be covered and knowledge that children should have gained by the end of the school entrance phase as well as the end of primary school. However, in addition, there are clear outlines of so-called 'process-related competences' that students should acquire throughout their school time.

Some of the competences are in line with the 21st century skills outlined in the frameworks and studies mentioned in the previous chapter but overall the skills seem to be more classroom specific. One aspect that seems to receive much less emphasis within the NRW curriculum is creativity. On the other hand, both problem-solving/critical thinking and communication

are described clearly. It becomes apparent that the interconnectedness of skills is recognized while at the same time explicit developmental expectations are given.

Overall, communication skills within the context of mathematics education are clearly defined and provide educators with detailed descriptions on what to expect of students in the classroom.

3 Communication Skills and how they can be developed in school

3.1 General Understanding of Communication Skills

While there might be minor differences in the skill sets suggested by researchers and organisations, there seems to be a consensus on a few main skills, such as creativity or critical thinking. Another skill set which continues to be emphasised is communication. In order to figure out how communication skills can be developed, a better understanding of these skills and how we can interpret them in the context of education is needed. As Fadel et al. (2015) highlight, communication skills are required on a daily basis in all professions, for instance in the form of “negotiating, giving instructions, advising, building relationships, [or] resolving conflicts” (p. 77). Effective communication is crucial to avoid miscommunications (Scott, 2014). According to Looser and Elsässer (2021), strong personal competences also relate to one’s self-esteem, optimism and psychological and physical wellbeing. Solórzano et al. (2018) state that the benefits of skill development go beyond education and will positively and long-lastingly impact students’ health and happiness. Karasheva et al. (2021) share this view and state that the degree to which communication skills are developed will have an impact on the personal development of the child as a whole.

Additionally, in the context of school, social interactions play a deciding role in successful learning (Wettstein & Raufelder, 2021). Furthermore, Wubbels et al. (2015) have found a link

between positive relations and certain student behaviour, such as prosocial behaviours, high wellbeing, high self-control or friendships and positive relations among students. Furthermore, tasks that explicitly support communication and collaboration will allow for differentiated and inclusive learning for all students (Häsel-Weide & Scherer, 2019). The OECD (2019) sees communication as part of a social and emotional skill set which enables learners “to develop themselves, cultivate their relationships at home, school, work and in the community, and exercise their civic responsibilities” (p. 4).

Chalkiadaki (2018) points out that communication skills are mostly considered in close connection with collaboration skills. Nonetheless, communication skills can be seen and defined as a separate entity. A general definition of communication is “the act or process of using words, sounds, signs, or behaviours to express or exchange information or to express your ideas, thoughts, feelings, etc. to someone else” (Merriam-Webster, 2022). The term can be traced back to the Latin ‘communicare’ which translates to inform and is closely connected to the term ‘communis’ which translates to together. Given that communication is one of the main competencies set forth in the curriculum, mathematics can thus be seen as a ‘social process in exchange with others’ (Brandt, 2019, p.9).

A distinction may be made between oral and written communication (P21, 2019; Chalkiadaki, 2018; Scott, 2015) but many descriptions are true for both aspects. Overall, communication is concerned with expressing one’s thoughts, ideas and opinions in a clear and understandable way (P21, 2019; Scott, 2015).

P21 (2019) views communication as being closely connected to collaboration. Their framework provides a comprehensive overview of the skills and their components and will therefore be used as a main source going forward. Communication does not only involve the output of language, but it also requires effective listening skills for students to interpret information, values or intentions conveyed towards them. Respectfulness towards other team members, flex-

ibility and the willingness to make compromises are all part of successful communication. Furthermore, each contributor to the communication is valued and shared responsibility should be taken.

With the recent developments of technology, much communication takes place digitally. When looking at the context in which the research is conducted, it becomes obvious that many schools are still lacking the necessary media to implement learning through and with ICT (Mußmann et al., 2021). Thus, this research is not concerned with students' digital communication skills.

3.2 Communication Skills and their Development in the Context of Mathematics

According to P21 (2019), students should be able to use effective communication in a variety of environments. This means that effective communication should be encouraged across all areas of learning as this will allow for skill transfer outside the classroom. Nonetheless, Jonsson et al. (2014) argue that a majority of mathematics lessons are spent on algorithms that focus on fast ways of solving tasks. While this approach may be appropriate in several situations, it is not an indication of students' actual understanding of mathematics. Rosdianti et al. (2020) point out that, according to teachers, communicative tasks are a good way of checking students' understanding and the achievement of learning objectives. Additionally, they also outline the benefit of communication skills that transfer beyond the classroom. Palinussa et al. (2021) add to this, that students will benefit from strong communication skills in solving mathematical problems. Furthermore, Triana et al. (2019) state that communication in mathematics, both verbal and non-verbal, will enhance students' understanding of this subject.

The subject of mathematics lends itself to collaborative tasks that allow students to utilise and practice mathematical and non-mathematical communication skills. In fact, Trisnawati et al. (2018) underline the importance of communication amongst students in achieving the learning objectives and making learning more meaningful.

An evident factor in the development of communication skills are the opportunities provided to students that allow them to use and develop communication skills. Rosdianti et al. (2020), point out that communication in the classroom may take place in many forms, such as interactions between students, responding to questions, completing tasks and various other verbal and non-verbal activities. However, this does not mean that communication skills develop on their own (Karasheva et al., 2021). As reported by Triana et al. (2019), communication within the context of mathematics includes the presentation of mathematical ideas in a variety of forms, expressing and justifying ideas, posing and explaining questions, and the exchange of ideas. Moreover, they state that teachers should strengthen students' skills by providing ample opportunities for students to use communication. Fadel et al. (2015) highlight that collaborative tasks are among the most important ways to support and assess the development of communication skills. Additionally, students can teach their classmates or younger students as a way of improving their communication skills. Fröhlich and Prediger (2008) point out that research has shown students to be overwhelmed with cooperative problem-solving and argue that students would often not reach the standards for communication skills as described in the curricula.

In their earlier research, Fröhlich and Prediger (2008), take apart the mathematical communicative competence, as stated in the curriculum at the time, for further analysis:

- Communicating refers to the exchange between people with different goals, means or contexts.
- Presenting refers to mostly one-sided communication with the goal to inform or persuade.
- Arguing focuses on content specific aspects with the goal to persuade or justify.
- Representing refers to linguistic and non-linguistic means of communication, argumentation or presentation.

- Cooperating refers to joint processes that serve exchange of information or the production of a product.

The authors emphasise that during the learning process, the different areas of communication skills are closely intertwined and often happen simultaneously. One can deduct that a balance of task types must be provided which allows students to practice their communication skills in all aspects.

When looking at task forms that support the development of communication skills, a major factor becomes apparent. Palinussa et al. (2021), investigated realistic mathematics education and its effect on students' mathematical reasoning and communication skills and found significant differences at all levels. They argue that mathematics education must be linked closely and be relevant to the reality of the child. Tasks that are linked to realistic, daily contexts will enable students to understand problems more easily and support easier communication between children (Palinussa et al., 2021). Fröhlich and Prediger (2008) share this view as they claim that the first step is to provide authentic occasions for communication, in which precise and effective communication is essential.

Communication within mathematics is not always needed or appropriate. Fröhlich and Prediger (2008) state that, in the practice of standard methods, there is not necessarily a need for communication or collaboration. In fact, this may be limited to the comparison of results. One option to implement communication at this stage of learning would be a joint search for mistakes.

However, when new problems are encountered for which students have not yet learned standard methods, the exchange of ideas with peers can be valuable for finding approaches or ways of solutions (Fröhlich & Prediger, 2008).

Fröhlich and Prediger (2008) are also among the few authors who have given an outline for tasks that encourage and enhance communication. According to the authors these tasks can be described as:

- sufficiently challenging and complex to enable students to share their problems or solutions in a group;
- challenging in a way that shows learners the benefits of working with others;
- enabling a variety of ways to get to a solution;
- having the option to be solved on different levels;
- having a focus on representations as a central part to mathematical thinking; and
- enabling the evaluation and comparison of ways to get to a solution.

An issue with tasks in mathematics lessons may be the language, as it requires familiarity with a large amount of terminology, special sentence structures and text types, such as definitions or word problems (Prediger & Meyer, 2012). However, the authors argue that one should not react to the challenge of language by continuously simplifying language in textbooks and classrooms as the ultimate educational goal is for students to also be able to detect more complex connections and express these. They call the simplification of language a defensive approach and recommend an offensive approach instead. Prediger and Meyer (2012) suggest providing students with vocabulary that will support them in communicative tasks. However, rather than isolated words, whole phrases should be collected or provided in **vocabulary banks**, especially for second-language learners. Brandt (2019) additionally emphasises the potential of **different forms of representation** in helping students with restricted language to communicate clearly. These points are especially relevant given the context of the research. Within school statistics, students who were born abroad and immigrated to Germany, students with at least one parent born abroad or students whose main home language is not German, are considered as students with an immigration history. In recent years, that share of students has continuously grown. In the school year 2018/19, 36.9%, in 2019/20 38.2% and in 2020/21 39.4% of students had an immigration history (*NRW*, 2021; *Anteil der Schülerinnen*, 2020). This means that the provision of vocabulary is especially important.

3.3 Summary and Conclusion of the Chapter

Communication skills are an essential skill for children to acquire as they influence, not only their life in school but their development as a person, as it leads to stronger relationships, helps children to avoid misunderstandings and influences their overall well-being (Looser & Elsässer, 2021; Karasheva et al., 2021). Furthermore, within the mathematics classroom, communication plays a role in students' mathematical understanding.

Both, the NRW curriculum, as seen in the previous chapter, as well as other studies outlined above, recognise mathematics as a subject that should be taught with sufficient opportunities for communication and cooperation. The criteria for communicative tasks as outlined by Fröhlich and Prediger (2008), also agree with expectations set by the curriculum. The exploration and explanation of a variety of methods is emphasised, as well as forms of representation. An expectation for children at the end of year 4 is the ability to use appropriate terminology. Within this chapter, it became apparent that vocabulary banks are a critical tool in supporting students' language development for communicative tasks.

An aspect that was highlighted by the studies presented in this chapter but no within the curriculum, is the need for authentic tasks, that are connected to the world of the children.

4 The Role of Textbooks in Education

Within this research a definition as suggested by Van Steenbrugge et al. (2013) is used for textbooks. The term "refers to the printed and published resources designed to be used by teachers and students before, during, and after [mathematics] instruction" (p. 323). It is worth noting that 'mathematics textbook' may be simplified to just 'textbook'.

Well-designed textbooks can involve students in different ways and have potential for "fun, lasting and meaningful learning" (Behnke, 2018). Despite their important role in the classroom, which will be highlighted in the upcoming paragraphs, studies on textbooks were scarce until two decades ago. In the early 2000's research in the field began to grow and textbook analysis

became a more common topic of study, providing valuable insights for teaching and learning processes. Nonetheless, Fan (2013) argues that the mathematics textbook research still appears to be “at an early stage of development as compared with many other fields of research in mathematics education” (p. 766). The following sections will highlight different roles of the textbook in today’s education.

4.1 Textbooks as the Main Tool in the Classroom

Textbooks have served as one of the main tools for classroom instructions for decades (Mullis et al., 2012; Van Steenbrugge et al., 2013; Foster, 2015; Glasnovic Gracin, 2018; Divrik et al., 2020). According to O’Keefe (2013) textbooks are still a main part of the learning process and play an important role in shaping teachers’ and students’ view of a particular subject. Van den Ham and Heinze (2018) found that 49-64% of teachers from Grades 7 to 9 in Estonia, Finland and Norway reported to heavily rely on the textbooks in the preparation of their lessons and 79-92% stated the textbook to be their only source for exercises in the majority of their lessons. In a survey in connection with the TIMSS study, 86% of German teachers reported that the mathematics textbook forms the basis of their instruction (Mullis et al., 2012).

In an earlier research, Vincent and Stacey (2008) noted that especially beginning teachers and teachers without mathematical background rely heavily on the textbook. In a more recent study, Lepik et al. (2015, as cited in Van den Ham & Heinze, 2018, p. 134) found that most problems for students’ in-class exercises and homework were taken from mathematics textbooks and Glasnovic Gracin (2018) states that textbooks are used even more in lesson preparation than the curriculum outline. Given its extensive use in the classroom, we can conclude that textbooks research is an important field of research for the continuous improvement of education.

4.2 Textbooks and Learning Outcomes

The results of research that investigates the influence of textbooks on students' learning tend to vary. Nonetheless, several studies over the past decade have found relevant differences in outcomes for students' learning depending on the textbook used.

Steenbrugge et al. (2013) conducted a research in Belgium in which they did not find different mathematics textbooks to have significant effects on students' achievement. However, in a longitudinal study Van den Ham and Heinze (2018) found that "textbook choice has a substantial effect on the students' arithmetic achievement in Grade 1 and 2" (p. 138). Their results indicate that the effect of different textbooks may accumulate over a school year. Shield and Dole (2013) noted a difference in students' use of adaptive expertise depending on the textbook.

In a recent research, Sievert et al. (2019) investigated the impact of different mathematics textbooks on students' adaptive expertise. They revealed substantial effects of the textbook on student outcomes. The development of adaptive expertise depended "on the variety of strategies and related tasks presented in the learning resources" (p. 10). The findings of Sievert et al. (2019) are especially relevant to this study because their research was conducted in a similar context as the one presented in this paper. Sievert and his colleagues analysed the four most common textbooks from Year 1 to Year 3 in NRW of which one was selected for this research.

Overall, studies suggest a positive effect of textbook choice on the quality of students' learning. Nonetheless, open questions remain (Van den Ham & Heinze, 2018). Most research has been focused on textbook potential regarding mathematics achievement rather than skills development.

4.3 Textbooks as the Potentially Implemented Curriculum

Textbooks play a crucial role in translating curricular frameworks into learning activities (Bellens et al., 2019; Rahimah & Visnovska, 2021). You et al. (2019) argue that “textbooks are the prime vehicles communicating national curriculum aims directly to the country’s learners” (p. 2) and Glasnovic Gracin (2018) adds that in the US, teachers tend to base their classroom practice more on the textbooks than on what is written in the curriculum.

According to a framework used in the TIMSS study, one can distinguish between the intended curriculum, the implemented curriculum and the attained curriculum (Bellens et al., 2019). The intended curriculum refers to the national policies and standards of educational systems whereas the implemented curriculum regards classroom practises and strategies of teachers. The attained curriculum describes the objectives that students ultimately achieve. Valverde et al. (2002) see the textbook as an additional field that can form a link between the two dimensions of the intended and the implemented curriculum: *the potentially implemented curriculum*. They conceptualise the textbook as a mediator between the intended curriculum as the official policies and the curriculum that is implemented by teachers. Son and Diletti (2017) view teacher manuals, students’ textbooks and workbooks and supplemental materials to be part of the potentially implemented curriculum.

In the light of curriculum reforms, new textbooks should “go beyond the imparting of subject matter to students and to help teach competencies [and] skills” (Behnke, 2018). However, Behnke (2018) also argues that most textbooks do not fulfil the curricular requirements regarding the support of skill development. The following section will outline the current status of textbooks in relation to the development of skills and competencies.

4.4 Research on Textbooks and Skill Development

According to Chabbott and Sinclair (2020) most older textbooks do not yet address the skills and knowledge of the 21st century. But students' way of thinking and their view of subject matter is influenced by different types of tasks (Glasnovic Gracin, 2018). Nonetheless, textbook research regarding the development of 21st century skills is still scarce, and the author of this thesis did not have access to all available studies.

Glasnovic Gracin (2018) examined whether Croatian textbooks offered a range of task types. She found that there is little balance between the different tasks and that "authentic context, open-answer tasks and reflective thinking skills are not required at all" (p. 18) which is not in line with the mathematics requirements of Croatia.

In a case study of Turkish primary mathematics textbooks, Divrik et al. (2020) found that teachers reported a lack of quality in problem-solving tasks and that little opportunities were provided to link tasks to their everyday life and develop practical thinking skills. In another study, Kul et al. (2018) compared the opportunities for higher order thinking skills such as 'cognitive processes' based on a synthesised Bloom's Taxonomy in Turkish and Canadian mathematics textbooks. Their findings suggest little encouragement for higher-order thinking skills (HOTS) in Turkish middle school textbooks, with a large amount of multiple choice, fill-in-the-blanks and matching questions. Canadian mathematics textbooks put more emphasis on the development of such thinking skills with more options to explore and a large number of open-ended questions.

Hadar and Ruby (2019) explored the alignment of Israeli textbooks with the curriculum and found that the textbooks did not meet the expectations of policies.

In a research on Rwanda's competence-based curriculum and their textbooks Ndihokubwayo & Habiyaremye (2018) highlight teacher trainees' views of competence-based textbooks. While many strengths and weaknesses are related to structures, usability, and overall design, some benefits include more learner-centred activities and the use of Bloom's

taxonomy levels. On the other hand, teachers were not satisfied with the lack of connection to real-life situations and the inconvenience of some activities needing expensive materials.

Overall, it can be said that tasks are initiators for activities and both, balance and variety of task types are needed (Glasnovic Gracin, 2018). More research in the field is needed to find out more specifically how textbooks may support the development of skills next to the acquisition of content.

4.5 Covid-19 and School Closures

Strict lockdowns as a consequence of the Covid-19 pandemic continue to force education systems worldwide to deal with unprecedented school closures (Kuhfeld et al., 2020) and to provide their students with quality education without in-person instruction.

Many countries faced the issue of gaps in access to technology, both in schools and in the homes of students. Furthermore, teachers had insufficient training and experience in teaching virtually (Kuhfeld et al., 2020). Digitalisation has been a heavily criticised issue in Germany for years. According to Irion & Zylkas (2020), the Covid-19 pandemic once again showed that Germany neglected digitalisation in educational institutions. They argue that primary schools should have long been equipped with child-friendly digital media. However, the majority lack age appropriate learning platforms and most students do not have their own device for digital learning (Irion & Zylkas, 2020). Irion and Zylkas (2020) also found that, during the first lockdown, primarily high school students from Grade 5 and onwards participated in video conferences with their teachers. Virtual learning is uncommon among primary school students.

Brenan (2020) found that in the USA 83% of parents reported that their children participated in a school-based online learning program. In Germany, only about 59% of students between the ages of 10 and 15 made use of learning platforms during the first quarter of 2020 (DeStatis, 2021). In a survey from April 2020, 79% of primary teachers named task sheets as a form of instruction whereas only 9% reported the use of video conferences (Anders, 2020). A follow up survey from December 2020 showed minor improvements but still nearly three quarters of

primary teachers felt unprepared for the return to remote learning as part of the second lockdown in Germany (Kuhn, 2021).

Little opportunities for online learning meant that students often received weekly assignments that were to be done individually at home. Thus, students had to work on tasks independently, possibly with the help of a parent but without the support of a teacher. While some teachers may have used worksheets, the textbook also became an even more important tool for students' learning.

Chabbott and Sinclair (2020) argue that "the future of sustainable Development Goal (SDG) 4 depends on education systems being better prepared for another crisis" (p. 51). They have identified three main areas for investments into the future of education, one of them being textbook accessibility and quality. The Covid-19 pandemic has shown that due to inequalities in access, schools cannot solely rely on digital learning tools. Some children will be able to do little at home without textbooks, so immediate investments in textbooks are crucial, even if they may seem sacrificial at the time (Chabbott & Sinclair, 2020).

Even with online learning systems in place, teachers acted more as advisers (Carpenter & Dunn, 2020) and the learning process could be challenging. A study by Kuhfeld et al. (2020) indicated "that students may be substantially behind, especially in mathematics" (p. 561). It can thus be said that an effective textbook is crucial to support student learning during an exceptional situation such as a pandemic where learning in classrooms may not be possible for extended periods of time.

4.6 Summary and Conclusion of the Chapter

Textbooks form a major component in learning and teaching. They can be seen as the implemented curriculum, thus transferring outlines from the curriculum documents to the classroom. Additionally, many teachers report the textbook to be the main resource in their planning. Nonetheless, studies have found that textbooks do not always align with the curriculum and may sometimes offer only a narrow range of task types.

While their importance in the classroom is understood, it appears that research in the field still needs to be developed further, especially with regards to skill development. The Covid-19 pandemic has shown the need to invest in effective textbook research to ensure the Sustainable Development Goal 4 in the future.

5 Research Design and Methodology

5.1 Case Study

The research is a case study because it aims to “closely examine data within a specific context” (Zainal, 2007, p. 1). This study provides an in-depth analysis of a specific textbook with regards to specific criteria. According to Hitchcock and Hughes (1995, as cited in Cohen et al., 2018), a case study may focus on individuals’ perceptions of events; this research intends to closely examine teacher’s views of the Zahlenbuch with interviews conducted with teachers of one school in the German state of North Rhine-Westphalia.

Although it is difficult to generalise data collected from case studies (Blaxter et al., 2010; Zainal, 2007), data is collected and examined within its context and can help to describe or explore the environment authentically (Zainal, 2007).

5.2 Literature

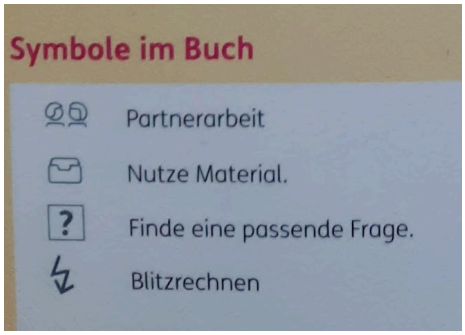
By answering the first and second sub-question through literature research, bias can be prevented in the textbook analysis since newly acquired information can be placed “in the context of what is already known about the issue” (Blaxter et al., 2010, p. 122). Therefore, a thorough literature review strengthens the research design.

Information was gathered from studies to establish a solid basis for the practical part. Overall, significant sources from a variety of contexts and countries have been chosen. Articles stem from educational journals or online educational databases, to ensure their credibility.

5.3 Textbook Analysis

Sub-question three is answered through the use of a textbook analysis. The analysis encompassed the German textbook Zahlenbuch 4, which is one of the most commonly used mathematics textbooks in German primary education. Son & Diletti (2017) state that complete frameworks for the analysis of textbooks are yet to be developed. This holds especially true with regards to skill development. Still, three main approaches to textbook analysis can be determined: critical discourse analysis, multimodal analysis and content analysis. For this study, a content analysis was conducted which is an "interpretation of the content of the text data through the systematic classification process of coding and identifying themes or patterns" (Dewayani et al., 2020, p. 128).

This research will follow content analysis as described by Krippendorf (2013), who identifies several components within the data collection. The upcoming paragraphs will outline the steps taken in analysing the Zahlenbuch.



Unitizing and Sampling involves distinguishing units of content that are or value to the analysis (Krippendorf, 2013). The researcher chose to analyse two textbooks, the Zahlenbuch 3 and the Zahlenbuch 4. As the focus is on communication skills, the chosen units of texts are tasks which are marked as partner exercises by the textbook. These are accompanied by a symbol and are thus easy to recognise. To make the project feasible and concentrate the analysis on the relevant information, other tasks were mostly disregarded.

The next step is the coding of data which allows the transformation of text into representations which are apt for an analysis (Krippendorf, 2013). Codes for the analysis were created using the theoretical framework. Common themes within the NRW curriculum and literature

on communication skills and their development were identified and the following three codes were established:

1. Authentic Tasks
2. Vocabulary Provided
3. Different ways for a solution (verschiedene Lösungswege)

In order to prevent bias and efficiently code the communication tasks, the understanding of the codes was clarified.

'Authentic tasks' refer to the connection of exercises to children's real-life experiences. A definition by Tan and Nie (2015) was used to support the textbook analysis. According to the authors, authentic tasks should:

> "[provide] opportunities for pupils to apply ideas to everyday non-school-related situations, [focus] the lesson on what is personally meaningful rather than what is in the syllabus, [attempt] to link subject knowledge to their personal experiences, [and provide] opportunities for them to apply ideas learnt in class to other subjects" (Tan & Nie, 2015, p. 4).

The code '**vocabulary provided'** refers to the need of vocabulary banks, presenting either terminology or useful phrases. A first impression of the book showed that supporting language would sometimes be provided separately on a page and connected to several tasks. Hence, it was decided that vocabulary banks would not have to be directly linked to a task but would have to be present on the same page.

For the third code, '**different ways for a solution'**, the connotations and implications of the German 'verschiedene Lösungswege' do not directly translate into English without losing some of their meaning. Thus, the researcher decided to keep the German phrase as an addition. This code refers to the possibility of solving a task in more than one standard way and using different representations. Tasks with different ways for a solution could also allow for possibilities to exchange, evaluate or compare ideas.

It is important to note that not all indicators of tasks that encourage the development of communication skills are clearly measurable. Therefore, the codes excluded the following aspects:

- *Tasks are sufficiently challenging*. It would not be possible to analyse tasks without bias, due to external factors such as class size, students' prior learning experiences or the learning environment.
- *Tasks can be solved on different levels*. This code would refer to the possibility to differentiate tasks for students but external factors, such as the teacher's knowledge, prevent clear analysis of tasks.
- *Communication for different purposes*. Initially, the following categories had been established: exchanging ideas; informing; arguing, justifying and persuading; and representing. However, the communication purposes heavily depend on the way that the task is being completed at school and how it is introduced by the teacher.

The final step in data collection according to Krippendorf (2013) is the reduction of data, leading to quantifiable results and efficient representation of data. Based on the coding, tables and frequency charts can be created.

After collecting the data, inferences can be made about the meaning and significance of results in connection with the existing theory (Weninger, 2018).

5.4 Interview

Questionnaires are widely used research instruments for data collection, can be administered without the presence of a researcher and are usually 'comparatively straightforward to analyse' (Cohen et al., 2018, p. 471). However, upon careful consideration, the researcher decided that semi-structured interviews were better suited for the main data collection of the study. Knowledge can be seen as constructed through conversation between humans (Cohen

et al., 2018), so an interview allowed for clearer collection of data. It was an especially appropriate method of data collection given that the presented research is a case study, focussing on a smaller sample of participants but seeking in-depth answers.

Cohen et al. (2018) state the importance of specifying the issues to be discussed in advance as it makes data collection more systematic. For this study, semi-structured interviews were conducted. This meant that the questions were decided in advance; however, they are open-ended, and the phrasing or order could be adapted to each respondent (Cohen et al., 2018). Furthermore, the semi-structured interview left room for questions of clarification or spontaneous questions to seek out more information from a certain answer.

Based on the theoretical framework and the rough textbook analysis, the following interview questions were developed:

a) Which edition of the mathematics book are you using? How long have you been working with the Zahlenbuch?
b) Which role does the mathematics book play in the planning of lessons?
c) Which role does the curriculum play in the planning of lessons?
d) What impact do the new changes to the curriculum play in the planning of lessons?
e) From your viewpoint, do the math books provide sufficient opportunities to acquire and deepen knowledge through cooperative work forms?
f) What are the differences in your use of the workbook as compared to the student book?
g) Are partner or group tasks comprehensible and accessible for all students or is (much) help and modelling from the teacher needed for effective learning?
h) Which wishes/requests for change would you have for the mathematics book or the curriculum with regards to communicative skills?

The questions were sent to the participants shortly in advance of the interview to allow them to have more time to consider their answers.

Given that there is a lack of theory in the field of study that is being researched, it was key to select a method for analysing the data that would allow the generation of first tentative theoretical concepts. Therefore, grounded theory has been chosen as the approach to data analysis. A key feature of grounded theory is that “theory derives from the data; it is grounded in the data and emerges from it” (Cohen et al., 2018, p. 714). Rather than examining the data based on pre-determined frameworks, the researcher seeks to find patterns in the data (Newby, 2014).

Newby (2014) outlines the grounded theory approach in detail, describing it as a process that consists of three stages which were followed by the researcher. In the first stage, a set of open codes was developed through substantive coding. Through (re-)reading the data and writing down ideas, codes emerged that describe the essence of different meaningful segments of data. Next, codes were grouped together under overarching themes by using selective coding. According to Newby (2014, p. 493) “the process seeks to find a link between codes that will bind them to a core idea, the theoretical code”. Lastly, through theoretical coding, explanations can be sought with the overall aim to generate theory.

While working through the stages, two processes reoccurred, the first one being memoing. Memos are typically written by the researcher to him/herself and can be comments, ideas, thoughts or suggestions which may later contribute to the formulation of theory (Cohen et al., 2018). The second process is referred to as constant comparison and describes the examination of overlap between codes in order to gain as much meaning from the data as possible with the smallest number of codes necessary (Newby, 2014).

As suggested by Cropley (2002), prior to the analysis the transcripts were summarised and clarified. Summarising “involves eliminating irrelevant material … (e.g., hesitations, repetitions…)” (p. 117) whereas clarifying is concerned with restating what has been said without changing the meaning while making the text less ambiguous.

5.6 Reliability and Validity

Both, reliability and validity are key factors to effective research (Cohen et al., 2018). A research can be considered reliable if another researcher were to find similar results to the same question in the same setting (Blaxter et al., 2010); a clearly set out research design which prevents biases is essential. Therefore, the research was designed according to the concept of triangulation. According to Blaxter et al. (2010), triangulation refers to the process, "where two or more methods are used ..., to try to verify the validity of the information being collected" (p. 85). By combining the results of a literature review, a textbook analysis and an interview, data is compared in several ways which prevents bias and therefore enhances both the reliability and validity of the research.

A valid research measures what it claims to measure (Van der Donk & Van Lanen, 2016). Next to triangulation, this study is adhering to several principles for qualitative research to ensure its validity. While a few priori categories for the interview analysis were used, most of the data analysis was completed inductively with the researcher being a key instrument in the research which is in line with suggestions by Cohen et al. (2018). According to Newby (2014), the collected data has to be representative of the issue that is investigated meaning that sampling plays an important role. Due to the Covid-19 pandemic, choosing samples was not as straightforward. Nonetheless, the researcher was able to choose highly qualified and experienced primary teachers from the one school for the interviews.

5.7 Ethics

To guarantee that the research complies with ethical guidelines, several precautions were taken according to guidelines as presented by Blaxter et al. (2010) and BERA (2011). Participation in the research project is voluntary and participants are free to pull out of the study at any point. The researcher approached the participants who agreed to take part in the study and a form seeking voluntary informed consent was sent out (BERA, 2011). To ensure as

much anonymity as possible, participants are referred to as respondents 1,2, and 3 rather than by name. Data from questionnaires is also anonymised. All data is stored privately, and recordings will be deleted upon successful completion of the study.

6 Development of Communication Skills in the Zahlenbuch

The Zahlenbuch is a series of mathematics textbooks which are published by Klett, one of the biggest companies for educational media in Germany, founded in 1957. In 1995, they published the first adaptation of the Zahlenbuch (*Geschichte*, n.d.) and have been revising the work ever since. The edition used for the textbook analysis is the newest one, published in 2017 which is also the one used by the teachers who were interviewed.

There are several types of books in the textbook series. A student book, a student workbook, practice books, student support books and a teacher handbook. Since the student book is intended for daily use in the classroom, whereas the others provide supporting materials and exercises, it was chosen as the object for analysis.

On the first pages, an overview is given regarding the structure of the book. Each chapter contains an introduction and important content, practice exercises and speed mental maths exercises. Special pages at the end of a topic each contain a review page with summarising exercises and an exploration page.

6.1 Presentation Textbook Analysis Zahlenbuch 4

As part of the first step of the content analysis, units of texts, in this case tasks, were selected to be analysed (Krippendorf, 2013). The Zahlenbuch 4 contains a total of 503 tasks, spread across 22 chapters. The book clearly highlights tasks that are supposed to be completed with a partner with a symbol. To make the analysis more feasible and to ensure validity

the analysis was limited to these communicative tasks. This reduced the number of tasks from 503 to 339 equalling about 67% of the total amount of tasks.

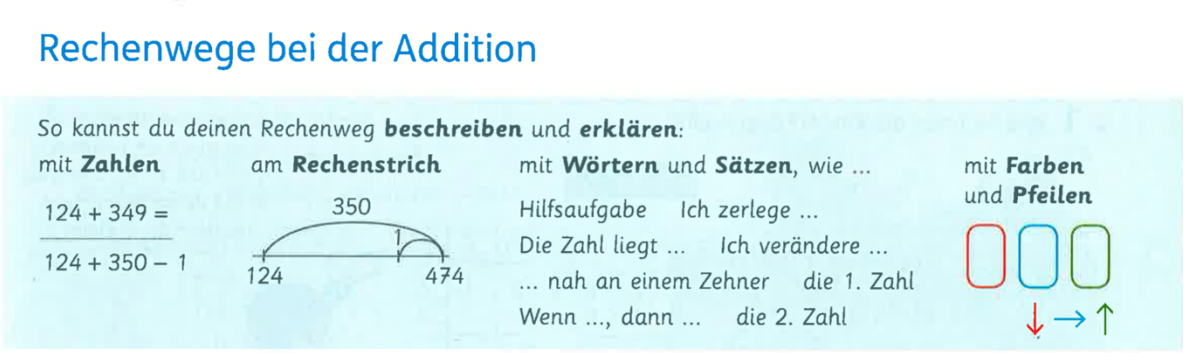
Next, the remaining tasks were categorised, using the pre-established codes:

- Authentic Tasks
- Vocabulary Provided
- Different ways for a solution (verschiedene Lösungswege)

For authenticity and solutions, if a task consisted of several parts and one of the sub-tasks fit the category, the task was coded as such.

For easy reference, each task was assigned a unique number combination, consisting of page number and task number. Task number one on page seventy-five would thus be 75,1. A excerpt of the textbook analysis can be found in Appendix A.

Figure 1: *Sample Vocabulary; page 8*



The book regularly provides vocabulary banks with a blue background (Figure 1). These will often be specific to not just one, but several tasks on that (double)page. In those cases, 'yes' was selected for the code '**vocabulary provided**' for all tasks on the page that the vocabulary bank was relevant to.

Figure 2: *Sample Task; 123,6*

The task above (Figure 2) will be used as a sample task to outline the coding process. The task is posed within the chapter 'Comparing Tasks' on the page about fractions.

Authentic Task: The task was coded as 'yes', because it attempts to link students' learning about fractions to their daily, non-school-related experiences.

Vocabulary Provided: On the same page spread, a blue vocabulary bank is provided, explaining how to write and name fractions. In addition, two prompts are given by the children in the picture. Hence, the task was coded 'yes' for 'vocabulary provided'.

Different Ways for a solution (verschiedene Lösungswege): The first sentence of the task translates to 'find different possibilities' and children are asked to draw and explain their ideas. As children are encouraged to find different ways to solve the problem and there is no prescribed way for drawing and presenting the result, the task was coded as 'yes' for this category.

6.1.1 Authentic Tasks

The majority of the tasks within the Zahlenbuch are not authentic tasks. Slightly more than one third of the analysed tasks can be considered authentic tasks. Some tasks were not clearly coded as yes or no, but rather as maybe. This is due to the potential interpretation and experiences of students. These tasks may be more meaningful to some but not all students.

Table 1: *Number of Authentic Tasks*

Authentic Task	Count of Page, Task/ Indicator	Count of Page, Task/ Indicator
maybe	18	5,31%
no	195	57,52%
yes	126	37,17%
Final Sum	339	100,00%

There were differences regarding the share of authentic tasks, depending on the chapter. For instance, only 3 out of 21 tasks within the chapter about written division were connected to students' experiences, whereas all 11 tasks within the chapter on measuring and sorting were authentic tasks.

Table 2: *Authentic Tasks - Introduction to written Division*

Authentic Task	Count of Page, Task/ Indicator	Count of Page, Task/ Indicator
no	18	85,71%
yes	3	14,29%
Final Sum	21	100,00%

Table 3: *Authentic Tasks - Measuring and Sorting*

Authentic Task	Count of Page, Task/ Indicator	COUNT von Page, Task/ Indicator
yes	11	100,00%
Final Sum	11	100,00%

6.1.2 Vocabulary Provided

There is an even split for tasks which have vocabulary provided and tasks which do not. When analysing one of the last chapters of the book, a third code which was not previously established, was added, namely ‘non-math’. This refers to tasks that provide language for students to discuss and solve a task which are not relevant to the mathematical procedures.

Table 4: *Number of Tasks with Vocabulary Provided*

Vocabulary Provided	Count of Page, Task/ Indicator	Count of Page, Task/ Indicator
no	155	45,72%
non-math	18	5,31%
yes	166	48,97%
Final Sum	339	100,00%

While most chapters also had a relatively even split of tasks with and without vocabulary provided, there were some chapters which leaned more towards one or the other.

Table 5: *Vocabulary Provided - Data, Frequency and Probability*

Vocabulary Provided	Count of Page, Task/ Indicator	Count of Page, Task/ Indicator
no	9	100,00%
Final Sum	9	100,00%

Table 6: *Vocabulary Provided - Orientation within Millions*

Vocabulary Provided	Count of Page, Task/ Indicator	Count of Page, Task/ Indicator
no	11	37,93%

yes	18	62,07%
Final Sum	29	100,00%

6.1.3 Different Ways for a Solution

Tasks that allowed for and encouraged different ways of finding or explaining a solution were in the slight minority.

Table 7: *Number of Tasks with different ways for a solution*

Different Ways for a Solution	**Count of Page, Task/ Indicator**	**Count of Page, Task/ Indicator**
no	198	58,41%
yes	141	41,59%
Final Sum	**339**	**100,00%**

Within most chapters the number of tasks that could only be solved one way or had a prescribed way of solving and representing the solution were higher. Several shorter chapters of geometry were spread throughout the book in which the average number of tasks with different ways of a solution was the lowest.

Table 8: *Different ways for a solution - Addition and subtraction up to a million*

Different Ways for a Solution	**Count of Page, Task/ Indicator**	**Count of Page, Task/ Indicator**
no	20	64,52%
yes	11	35,48%
Final Sum	31	100,00%

A chapter towards the end of the book focused especially on comparing different paths towards finding a solution. In this chapter, all tasks had several possibilities to be solved and no representation was prescribed by the book.

Table 9: *Different ways for solution - Word Problems comparing ways of solutions*

Different Ways for a Solution	Count of Page, Task/ Indicator	Count of Page, Task/ Indicator
yes	12	100,00%
Final Sum	12	100,00%

6.1.4 Combinations of Codes

When looking at the codes in combination, one can see that out of all partner tasks only 13 tasks showed a combination of all, authenticity, vocabulary banks and different ways for a solution, constituting 3.83% of all tasks. 54 tasks, 15,93%, did not fit with any of the codes provided. The largest group consisted of tasks that were not authentic and did not allow for different ways of solution but had vocabulary provided, with a total of 59 tasks, making up 17,40%.

Different Ways for a Solution	Vocabulary Provided	Authentic Task	Count of Page, Task/ Indicator	Count of Page, Task/ Indicator
yes	yes	yes	13	3,83%
yes	yes	no	50	14,75%
yes	yes	maybe	3	0,88%
yes	non-math	yes	11	3,24%
yes	no	yes	24	7,08%
yes	no	no	32	9,44%
yes	no	maybe	8	2,36%

no	yes	yes	37	10,91%
no	yes	no	59	17,40%
no	yes	maybe	4	1,18%
no	non-math	yes	7	2,06%
no	no	yes	34	10,03%
no	no	no	54	15,93%
no	no	maybe	3	0,88%

6.2 Discussion of Results

Overall, it can be said that there are many opportunities within the Zahlenbuch for communication between students. As Fadel et al. (2015) stated, one of the most important way in students' development of communication skills are collaborative tasks. Out of 503 total tasks, 339 were indicated as tasks to be done with a partner or in a group which means that more than two thirds of the tasks allow students to develop their communication skills. This also shows the alignment of the Zahlenbuch with the vision of mathematics within the NRW curriculum which states mathematics to be a constructive process. The textbook analysis has shown that the book embodies that view by enabling students to explore concepts together and exchange ideas.

While the large number of partner tasks signifies ample opportunities for skill development, the researcher noted that some chapters in fact, had only a few to no tasks indicated as individual tasks. Future research might thus be appropriate to examine to strengthen the opportunities in those chapters.

6.2.1 Authentic Tasks

Palinussa et al. (2021) underline the importance of tasks with realistic, daily contexts that are relevant to the children because it will not only enable understanding but also easier communication. The textbook analysis shows that efforts are made in the Zahlenbuch to give authentic tasks that make learning more meaningful for children, as almost 40% of tasks fall under that category.

Within the previous sub-chapter, it became apparent that there were large differences in the number of authentic tasks between the chapters. Upon closer inspection, it could be seen that chapters which were concerned with the acquisition of standard arithmetic methods, such as written multiplication or division had less authentic tasks, whereas chapters about, for instance, measuring, dealing with data or word problems had a significantly larger percentage

of tasks that were connected to children's experiences. It might be argued that this is due to the fact that within chapters on standard methods, the focus is on developing confidence and fluency in computation.

Still, there were tasks which, while they might be coded as authentic tasks, could have been made even more meaningful to children themselves.

Figure 3: *Authentic Task Class Field Trip*

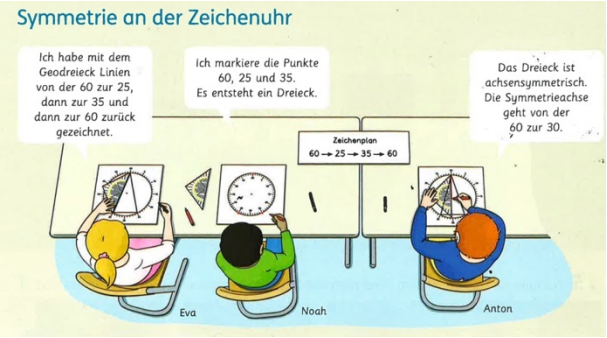
Page 114 and 115 were on the topic of comparing ways of solutions. Most tasks were categorised as authentic tasks, as they dealt with class field trips, which in German primary schools usually happen at the end of Year 4 and were thus a situation that children could easily imagine themselves in. The tasks were related to budgeting the trip and time planning. Yet, children were not given the opportunity to talk about their own experiences and choose activities which they would like to do from the table, which would have made the learning even more meaningful and allowed for easier communication.

6.2.2 Vocabulary Provided

Within the theoretical framework it became apparent that given the context of the study, vocabulary banks would play a crucial role in aiding students in their communication. According to school statistics, many students in NRW are second language learners (*NRW*, 2021). Already in the 1980s, Jim Cummins, a researcher in the field of bilingual education examined two types of languages. He states that children first acquire basic interpersonal communication skills (BICS) which they use to communicate with peers or parents in informal settings. However, at school they are required to make use of cognitive academic language proficiency (CALP) which refers to the academic demands, such as special terms for different subject

areas (Cummins, 1980). Within the Zahlenbuch, subject specific language which can be considered as CALP is provided regularly. The textbook analysis showed that blue vocabulary banks are spread mostly evenly throughout the book. Additionally, in almost all cases where new topics are introduced, the book provides the necessary vocabulary for learners to understand the concept and communicate about the content with their peers.

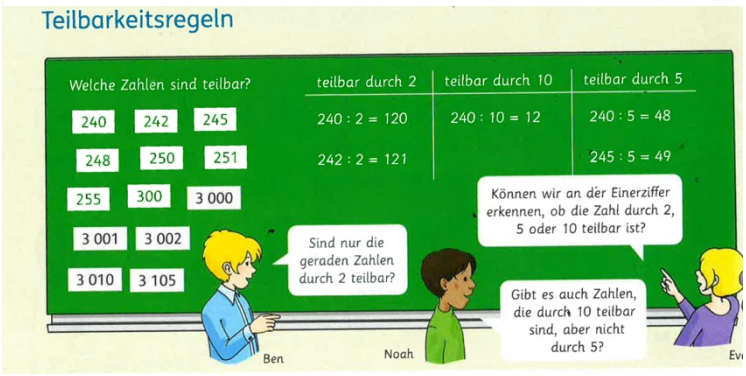
Figure 4: *Task Vocabulary Provided*



Meyer and Prediger (2012) stated that terminology should not be shown in isolation but rather integrated into phrases. This is not always the case within the vocabulary banks, where definitions of new terms were often given. However, within many of the images in the book, children can be seen talking, providing conversation prompts and using the terminology in a sentence. Figure 4 shows an image at the top of a page on symmetry. Below the picture, a blue vocabulary bank states the definition of axial symmetry. The picture puts the terminology into context and shows ways of using it in a sentence.

At times, word banks were not provided, and tasks required children to develop the necessary language on their own, for instance within the topic of divisibility rules.

Figure 5: *Task on Divisibility Rules*



The chalkboard shows the heading "Which numbers are divisible?" with several numbers underneath. A table has the sections "divisible by 2, divisible by 10, and

divisible by 5". The children in the picture are giving prompts such as "Are only even numbers divisible by 2?"

Task 3 on the same page required children to phrase the divisibility rules for 2, 5, and 10, using the picture prompt

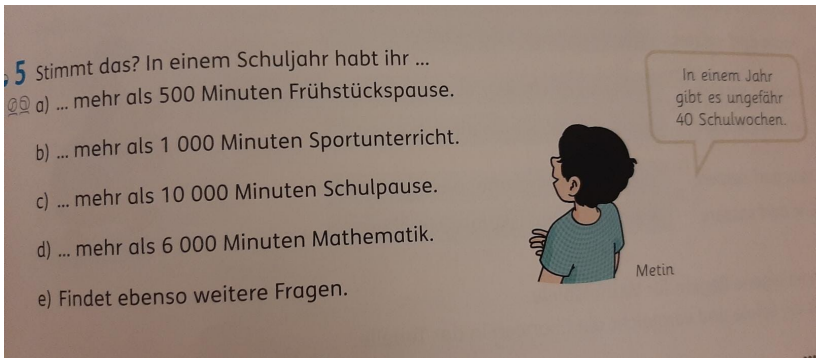
Prediger and Meyer (2012) argue against simplifying the language so that children may learn to detect and express complex connections. Within the Zahlenbuch 4, terminology is continuously given, and children are encouraged to use the language themselves through vocabulary banks and picture prompts. It can be said that the approaches are in line and that the Zahlenbuch takes an offensive approach to developing students' communication skills by providing support rather than a defensive approach by making language simpler.

6.2.3 Different Ways for a Solution

Tasks that can be solved in different ways allow children to exchange ideas, compare, argue and justify (Ministerium für Schule und Bildung, 2021; Fröhlich & Prediger, 2008). About 40% of tasks within the Zahlenbuch fit that category.

Figure 6 shows a task that allows different approaches to finding a solution. Children were asked to evaluate whether statements, such as "Within one school year you have more than 500 minutes of snack break" or "Within one school year you have more than 1000 minutes of PE", were true or false. Here, children might even reach different solutions based on their interpretation and will thus get to exchange their ideas and evaluate which way of solving the task seems more appropriate. As no major prompts are provided, students are furthermore able to explore different representations and strategies.

Figure 6: *Example Different Ways for a Solution*



One thing that could be noted during the textbook analysis was that, even if tasks encouraged different ways of solutions, different ways of representations were less encouraged.

Figure 7: *Non-example Different Ways for a Solution*

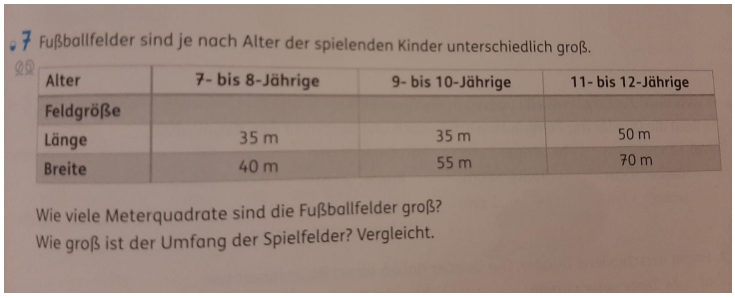
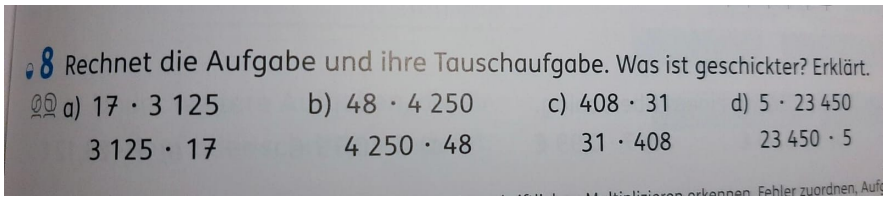


Figure 7 shows a task within the chapter of geometry that deals with area and circumference. Despite the fact that it is a mathematical concept that lends itself to the exploration of multiplication and can be made meaningful to students, all tasks had only one outcome and prescribed ways of solution.

6.2.4 Combinations of Codes

Almost 1/6 of all communication tasks did not fit with any of the codes that were applied during the textbook analysis. It is important to note, that this does not inherently make these tasks ‘bad tasks’. While tasks as the one below (Figure 8), are not connected to children’s real-life experiences, do not provide vocabulary and only leave room for one possible solution, they still allow students to express and exchange their ideas which is an important form of communication within the context of mathematics (Triana et al., 2019)

Figure 8: *Non-Example Task*



Nonetheless, only 13 out of 339 tasks could be indicated as 'yes' for all three codes. The three codes that were used for the textbook analysis were among the most important criteria for developing students' communication skills. So while there are ample opportunities for students to express their thinking and exchange ideas, skill development could be made even more effective by providing a greater balance of tasks.

7 Teacher's Perspectives on the Zahlenbuch

Initially, the researcher had intended to conduct five interviews with maths teachers from one school. However, due to a variety of reasons, ultimately only three interviews could be done. This means that data cannot be generalized for the wider scope of the issue. Nonetheless, the three teachers who participated, had considerable knowledge in mathematics teaching as well as experience with the Zahlenbuch.

Due to Covid, the interviews were conducted and recorded via Teams. They were transcribed, translated to English and subsequently coded and analysed using the grounded theory approach as outlined in Chapter 5. To ensure anonymity, the interviewees were given the names Respondent 1 (R1), Respondent 2 (R2), and Respondent 3 (R3). Appendix B provides an overview of the overarching themes, codes and content units that were identified as relevant to the analysis.

7.1 Presentation of Results

7.1.1 Planning

The first theme that emerged regards the **planning** of mathematics content.

All three participants discussed how the Zahlenbuch and the curriculum influences their planning and highlighted the role of curriculum alignment.

Respondent 1 described that the textbook is the main component to the planning of their lessons stating that they set their "*planning based on the Zahlenbuch*".

Respondent 2 and 3 described their views differently, saying the following:

"I always made sure that I worked through the contents of the book, but actually the curriculum was always in the foreground. " (R2)

"Everything that the Zahlenbuch does not cover enough for us […]we also take the curriculum to hand again.]" (R3)

They both explain that the curriculum mostly informs their planning at the beginning of the school year when they do their yearly preparations

These two respondents emphasised how the curriculum especially informed their yearly planning. Respondent 2 explained that they see the textbook more as a companion, supplement and mediator of the curriculum but that their focus is more on the curriculum and the content.

Still, both R2 and R3 recognize the importance of the textbook in the classroom.

"*The content of the number book is of course relevant for the majority of schoolchildren.*"(R2)

"*The Zahlenbuch is very extensive.*" (R3)

They explain that they use topic books as a supplement which are based on both, the curriculum and the content of the Zahlenbuch.

All three respondents mention the alignment of the curriculum and the textbook.

R1 state that they put their trust into the developers of the textbook and can rely on it to take the different areas of the curriculum into account. They add that following the textbook helps to ensure that all areas of learning are covered. R2 and R3 also mention that the "*Zahlenbuch mostly covers the curriculum*" (R3).

7.1.2 Process-related Competencies and Skill Development

All three respondents state that the Zahlenbuch offers a lot of opportunities for communication between students. Respondent 1 says that "*the Zahlenbuch has a lot to offer"* which Respondent 2 adds to by saying that the Zahlenbuch *"also considers the process-related competencies*".

Respondent 3 mentions that the "*tasks are already marked like this, and tasks that are particularly suitable are already very well chosen*"

All three respondents emphasise that the communication tasks allow students to exchange ideas and view the subject of mathematics in a different light.

R1 says that students realize maths is a subject "*where you don't just work on worksheets and calculate packets, but that math is also a thing you can talk about*"

The respondents also state the following:

"[*We can] look what different calculation methods we have and why which calculation method is particularly useful at which point and at which point perhaps not*" (R2)

"*Students realize, in mathematics there is not always just one way, but several ways, you did the math correctly, we did the math correctly, we have the same result, who now has the smarter solution*" (R3)

Overall the teacher's statements show satisfaction with the mathematics textbook with regards to opportunities for communication skills development, as based on the structure of the book, they have sufficient possibilities to stimulate cooperation.

One additional aspect that was discussed in the interviews were math congresses (Mathekonferenzen).

Students are usually "*first given a task and are supposed to calculate something and then try to explain to other children during the math conference how did I calculate that, how did I come to a conclusion*" (R1).

Respondent 3 explains that math congresses can be used when talking about "*larger, more extensive task*". Respondent 1 adds to this by saying that especially the tasks which are on "*a green background, so it looks like a chalkboard, where there are a lot of different tasks and different children calculate something*" lend themselves to be used for math conferences. Respondent 2 states that math congresses based on exercises of the book can be implemented well "*especially in phases of introduction into new content*" where content is often presented in a complex way which lends itself to embedding problem-solving and creativity.

Additional comments regarding the development of skills are made by Respondent 1 and. They state that they are currently teaching children who used a different textbook in the previous school year and that they see that "*they also have to get used to the Zahlenbuch now*" (R1). Furthermore, R2 says the following:

"*you have to pave the way for that (communication and cooperation) methodically in the 1 and 2*" and that "*has actually always been my goal, from 1 to 4 at some point, so that the children can act more and more independently*"

7.1.3 Approvals

A few common statements became apparent under the code for **approvals** of the Zahlenbuch.

Respondent 1 likes the practicality of having the mathematics book at hand and adds that there are lots of problems in the Zahlenbuch that she can easily use for math congresses as

the textbook is a medium that all students have at hand. They also state that once students get to know the book they can work well with it, also due to the symbols provided with tasks.

Respondent 3 shares that view as they say that the Zahlenbuch enables introductions to a new topic in the form of math congresses and states that there are sufficient tasks for communication and cooperation which are “well explained because they are chosen at the right place”.

Both, Respondent 1 and 2 mention the structure of the textbook and how they align across year groups. R2 also mentions that they like that the book opens up a new topic “in a complex and holistic way”.

7.1.4 Criticisms

When asked about wishes for change, all three teachers recognized that there is no perfect mathematics book. Still, they described a few criticisms.

Respondent 2 and 3 stated a general criticism of the book which is a view that they, however, do not share. Respondent 2 explains that it is often criticised that the book is very complex. As seen in the section above, R2 themselves, does not have an issue with this but recognized it, nonetheless. Respondent 3 gave the same description. They said that they hear statement from colleagues, such as “at this point I don't know how to explain the book page” or that “the book doesn't fit, they did that in an unfitting way”. They disagree with this view but also stated that they studied the subject as part of their degree and realize that it might have an influence on their view.

Respondent 1 mentions the same criticism. However, they agree with it as they say that sometimes “it is a little difficult, when you have children who are a little weaker” as the Zahlenbuch sets high expectations. They add another aspect by saying that they sometimes miss additional material to practise the automatization of standard procedures and often use additional materials, such as worksheets for support in that case.

7.1.5 Teacher's Role

All three teacher's highlight the teacher's experience and their role in the classroom as factors in using the textbook and developing communication skills in the classroom. Both R1 and R2 talk about how they can rely on their experience in the classroom:

"*You just know what is up, what do the children have to do*" (R1)

"*If you've been teaching for a long time, then maybe you don't look at it that much anymore, but already have it in your head how you want to do it*" (R2)

In addition, Respondent 2 and 3 highlight the importance of the teacher in helping their students develop communication skills. They mention that these do not develop by themselves and that certain work forms have to be taught and facilitated.

"I have to actively guide that and I have to have actively practiced that beforehand" (R2)

"*It's a given, of course that you have to introduce [cooperative work forms]"* and "[*you cannot say] let's do page 80, it's super great group work, do it yourself*" (R3)

According to R2, teachers will constantly need to reflect on their teaching and assess how to link the process-related competences with the content-related competences of the curriculum.

7.2 Discussion of Results

7.2.1 Planning

Mullis et al. (2012), found that the majority of German teachers use the mathematics textbook as the basis for their instruction. The interviewees mostly shared this view, as R1 stated that they use the Zahlenbuch as the basis for their planning. The fact that they put their trust into textbook developers to cover the curriculum content within their books, supports the statement of You at al. (2019) that the national curriculum aims are primarily conveyed to learners through the textbooks.

However, especially R2 also seems to view the Zahlenbuch as the potentially implemented curriculum in the way it was described by Valverde et al. (2002). They continue to highlight the need for alignment between the curriculum and the use of the textbook in the classroom. In fact, both Valverde et al. (2002) and Respondent 2 use the same term to describe the role of the textbook in the classroom, namely the term '**mediator'.** Whereas Behnke (2018) argues that a large proportion of textbooks do not yet take into account the curricular requirements regarding skill development, R2 finds that there is a link between the content-related and process-related competencies as outlined in the NRW curriculum, to be also found in the Zahlenbuch.

7.2.1 Process-related Competencies and Skill Development

Little research has been done on textbooks in connection with skill development. However, the studies that were conducted found that many textbooks were still lacking the necessary elements to support students' development of competencies (Divrik et al., 2020; Glasnovic Gracin, 2018).

On the other hand, all three respondents expressed their satisfaction towards the Zahlenbuch with regards to cooperative work forms. Respondent 2 made a direct connection to the NRW curriculum and the process-related competencies which are outlined by the ministry of education, saying that these are adapted well within the textbook. All three respondents statements showed that there the Zahlenbuch encourages communication for different purposes, such as exchanging ideas, justifying and comparing their results which is in line with the view of Triana et al. (2019) of communication within the context of mathematics who state that children should get to present their thoughts in a variety of forms. Furthermore, the responses are in line with the view within the curriculum which states that students should learn to explain their methods, record their results, put views into perspective and use appropriate terminology (Ministerium für Schule und Bildung, 2021).

In addition, the topic of math congresses (Mathekonferenz) was discussed during the interview. All teachers mentioned that they like to use certain tasks from the books, especially ones that stimulate children to think about different solutions to conduct these math congresses.

According to Fosnot and Dolk (2001), who are among the leading researchers in the field of mathematics education, math congresses “are more than just a whole-group share” (p. 29). They describe it as a work form that allows children to defend their thinking, generate ideas and communicate solutions, issues or ways of solutions. The role of the teacher can be seen as a facilitator of discussion and as a support to develop community norms. Based on the theory from Chapter 6 on tasks that encourage communication skills, it can be said that math congresses can provide solid opportunities for students’ skill development.

The view of Fosnot and Dolk (2001), is reflected in the teacher’s statement who highlight that math congresses allow students to exchange ideas and helps them come to the realization that there can be more than one way of solving the task. All respondents furthermore emphasised that math congresses provided ample opportunities for communication between students. While the teachers were satisfied with the tasks provided by the Zahlenbuch that can be used as a basis for math congresses, more research would need to be conducted to verify that view.

Respondents 1 and 2 also emphasised that communication skills do not develop themselves which is also stated by Karasheva et al. (2021). The teachers explain that skills have to be gradually built up from an early stage and developed through all ages. This is in line with Solórzano et al.’s (2018) view, who recommend supporting the development of skills across all subjects from as early as possible.

7.2.3 Approvals

Within Chapter 4 it became apparent that textbooks are one of the main tools in the classroom (Mullis et al., 2012; Van Steenbrugge et al., 2013; Foster, 2015; Glasnovic Gracin, 2018;

Divrik et al., 2020). The statement by Respondent 1 regarding the practicality of having it available at all times and all students may provide one reason.

7.2.4 Criticisms

It appears that the major criticism of the Zahlenbuch is the complexity of its tasks. However, this also appear to be a debated issue with arguments from both sides. Based on Respondent 3's statement, that some teachers might find it too complex to explain certain topics or do not know which work form to best implement, it can be concluded that a teacher's knowledge of the subject continues to stay crucial, no matter how well the mathematics textbook is developed.

7.2.5 Teacher's Role

All three respondents emphasised the role of the teacher in the successful development of students' skills. While they can rely on their experience to know how to select appropriate task types, they highlighted that cooperative work forms cannot simply be implemented in the classroom without prior instruction. In their chapter on math congresses, Fosnot and Dolk (2001) share this view. They state that teachers will need to establish routines for math congresses at the beginning of the school year and that hard work is needed to build a community of trust in the classroom, where children can share their ideas and communicate freely.

This research focused on the possibilities of the textbook. However, it appears that these are inextricably connected to the role of the teacher in the classroom. Furthermore, Respondent 1 added that sometimes cooperation does not work, not because of the tasks but because of the students' way of dealing with them. More research will be needed to connect the three components of the textbook, the teacher's role and the students' role in successful skill development.

8 Summary and Conclusion of the Research

This research aimed to examine the possibilities of the Zahlenbuch 4 in developing students' communication skills. A literature review was combined with a textbook analysis and teacher interviews.

Both, the textbook analysis and the interviews showed that the Zahlenbuch provides many opportunities for students to communicate with one another. The textbook analysis showed that more than two thirds of all tasks are indicated as communicative tasks which means that many possibilities were provided to develop students' communication skills. However, the textbook analysis also managed to provide a first indication towards not just the quantity of tasks but also of their quality. Based on the theoretical framework, three codes were applied to further analyse the tasks. About half of the tasks were connected to children's experiences, making them **authentic tasks**, which are especially useful in enabling students to develop their communication skills (Palinussa et al., 2021). Nonetheless, more opportunities could be provided to allow students to draw from their very own real-life experiences, making learning more meaningful and communication more authentic and thus more effective.

An aspect that was implemented well in the Zahlenbuch was the **provision of vocabulary banks**. Prediger and Meyer (2012) advise for an offensive approach in helping students acquire the necessary language, rather than a defensive approach in which language would continue to be simplified. The Zahlenbuch embeds this view by regularly providing definitions of terminology when new topics are introduced and having prompts and examples on how to use new vocabulary in a sentence. Overall, it can be said that, especially within the context of the study, where many students are second language learners of German, the Zahlenbuch provides many possibilities to develop their communication skills by supporting students with the necessary vocabulary.

The last code was that of **different ways of solutions (verschiedene Lösungswege)**. This code included different ways of solving a problem or representing a solution. Here, the

textbook analysis showed that about 40% of the tasks allowed students to find different solutions to a problem. However, it could be noted that different ways of representations were encouraged less often; rather, the task prescribed different ways to record results. Different ways of representation will not only allow for children to develop their own strategies, but it can also form the basis of a discussion in which children can exchange and justify ideas.

The interviews showed that teachers were especially satisfied with the provision of tasks that lend themselves to math congresses. Math congresses had not come up in the literature review but were discussed in the interviews. Teachers especially liked using problems that have a variety of solutions or ways to finding the right solution for these math congresses. This shows that the last code, is important in teacher's effective implementation of the textbook. Thus, it can be argued that improvements might be appropriate within that category. However, further research would be needed to clearly identify tasks that lend themselves for math congresses.

Overall, teachers were satisfied with the Zahlenbuch with regards to possibilities for development of communication skills. They state that many tasks provide opportunities for students to use communication for different purposes and to exchange ideas. However, support might be needed for teachers with less subject knowledge to support them in effectively implementing the tasks.

As a conclusion to the research, the research question can be answered.

What are the possibilities of the Zahlenbuch 4 in developing students' communication skills?

It can be said that the Zahlenbuch 4 makes a great effort towards the development of students' communication skills. The need for process-related competencies which is outlined in the NRW state curriculum is reflected in the student book and a majority of all tasks are indicated as partner or group tasks. Improvements could be made towards the quality of some

of the tasks. Communication skills are crucial skills, not only in developing children's mathematical understanding but, as part of 21st century skill, also in preparing them for life in a volatile and unpredictable future. In providing space for students to communicate amongst each other, the Zahlenbuch support their development.

8.1 Limitations of the Research

The researcher currently works abroad. Combined with school closures and strict Covid rules throughout Germany, it led to a small sample of teachers for the interview which presents the largest limitation of the research. A larger sample of teachers would have led to more comparable data as well as more valid and reliable results. Furthermore, it is difficult to draw generalizations from the results of a smaller sample.

Furthermore, only one textbook in the Zahlenbuch series was analysed and due to the large number of tasks and data, the textbook analysis was limited to fewer codes and focus points.

8.2 Recommendations for Further Research

Based on the limitations as well as the findings of this research, the following suggestions for future research can be made:

1. **A larger sample of teachers**. Questionnaires could be used to compare the views of teachers from different schools and provide a more generalizable overview.
2. **An extension of the textbook analysis throughout the entire series**. Both theory and interviewed teachers mentioned the importance of developing communication skills early and building them up over time. An analysis of all four versions of the Zahlenbuch may show if and how the Zahlenbuch supports skill development over time.
3. **Research on the teacher's role.** Another aspect that came up, especially during the interview, was the role of the teacher in implementing the textbook. Solórzano et al. (2018) state that teaching strategies can enhance or hinder skill development. Thus, further research is needed to investigate teachers' use of the materials and their strategies in teaching from and with the book and organizing communicative activities.
4. **Examining the teacher's guide**. Given the importance of the teacher in implementing the textbook, the teacher's guide could be reviewed to investigate how it supports teachers in implementing the textbook and give recommendations for improvement.

5. **Researching children's use and views.** Knecht and Najvarová (2020) emphasise the need to take into account students' opinions as they are the primary users of text-books but that their views tend to still be underrated

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10 Appendices

10.1 Appendix A

Extract Textbook Analysis

The tables below show an extract of the textbook analysis. The left column lists the page and task and the other three column the coding for the respective codes ‘authentic task’, ‘vocabulary provided’, and ‘different ways for a solution’. Due to the extensive amount of data, only a sample is provided in the appendix. Upon request, the complete tables are available.

Revision and Consolidation (pp. 4-19)

Page, Task/ Indicator	Authentic Task	Vocabulary Provided	Different Ways for a Solution
4,1	no	yes	yes
4,2	no	yes	yes
6,1	no	yes	no
7,4	yes	no	no
7,5	yes	no	no
7,6	yes	no	no
7,7	no	no	no
8,1	no	yes	yes
8,2	no	yes	yes
10,1	no	yes	no
10,4	no	no	no
11,5	no	yes	yes
11,7	no	yes	no

12,1	yes	yes	no
13,2	yes	yes	no
13,3	yes	yes	no
13,4	yes	yes	yes
14,1	no	yes	yes
14,3	no	no	no
15,8	maybe	no	no
17,5	no	yes	yes
18,8	no	no	no
19,1	no	yes	no
19,2	no	yes	no
19,3	no	no	yes

Authentic Task	**Count of Page, Task/ Indicator**	**Count of Page, Task/ Indicator**
maybe	1	4,00%
no	17	68,00%
yes	7	28,00%
Final Sum	**25**	**100,00%**

Vocabulary Provided	**Count of Page, Task/ Indicator**	**Count of Page, Task/ Indicator**

no	9	36,00%
yes	16	64,00%
Final Sum	25	100,00%

Different Ways for a Solution	**Count of Page, Task/ Indicator**	**Count of Page, Task/ Indicator**
no	16	64,00%
yes	9	36,00%
Final Sum	25	100,00%

Multiplication and division in the millions (pp. 66-75)

Page, Task/ Indicator	Authentic Task	Vocabulary Provided	Different Ways for a Solution
66,1	no	yes	yes
67,4	no	yes	no
67,5	no	yes	yes
67,8	no	no	no
68,1	no	yes	no
68,2	no	no	no
68,3	no	no	no
68,4	no	yes	yes
69,5	no	yes	yes

69,6	no	no	yes
69,7	no	no	yes
70,1	yes	yes	no
70,2	yes	yes	yes
70,3	no	yes	yes
71,5	yes	yes	no
71,6	yes	no	no
71,7	yes	no	yes
72,1	no	yes	no
72,2	no	yes	yes
73,6	no	yes	yes
73,7	no	yes	yes
73,8	yes	yes	yes
73,9	no	no	no
74,8	no	no	no
75,1	yes	yes	no
75,2	no	no	no
75,3	no	no	no
75,4	no	no	no

Authentic Task	Count of Page, Task/ Indicator	Count of Page, Task/ Indicator
no	21	75,00%

yes	7	25,00%
Final Sum	**28**	**100,00%**

Vocabulary Provided	**Count of Page, Task/ Indicator**	**Count of Page, Task/ Indicator**
no	12	42,86%
yes	16	57,14%
Final Sum	28	100,00%

Different Ways for a Solution	**Count of Page, Task/ Indicator**	**Count of Page, Task/ Indicator**
no	15	53,57%
yes	13	46,43%
Final Sum	28	100,00%

10.2 Appendix B

Interview Coding

Respondent 1

Overarching Themes (through selective coding)	**Open Codes (through substantive coding)**	**Content Units**
Planning	Zahlenbuch based	that surely is my main component of the lessons. I set my planning based on the Zahlenbuch.
	Curriculum based	now we must first see what changes, what may be added, what is omitted
	Curriculum alignment	[Using the textbook] ensured that you take into account all areas rely on the fact that the textbook takes the curriculum into account
Teacher's Role	Teacher Experience and	I don't look into the curriculum that often anymore

	Teaching to the Curriculum	you just know what is up, what do the children have to do
Process-Related Competencies	Textbook and cooperative work forms	I find that the Zahlenbuch has a lot to offer here
	Exchanging ideas	problems like this are raised and then they think, eh, why is that actually the case? What's happening there now? where you don't just work on worksheets and calculate packets, but that math is also a thing you can talk about
	Math Congress	these tasks with a green background, so it looks like a chalkboard, where there are a lot of different tasks and different children calculate something children are first given a task and are supposed to calculate something and then try

		to explain to other children during the math conference how did I calculate that, how did I come to a conclusion
	Early Development	came from a different textbook, they also have to get used to the Zahlenbuch now
Approval	Math Congress Tasks	take a lot of problems from the math book, because that's just a medium that all children have It's so handy because you have it at hand, it's there
	Structure of the Book	the topics that are being offered are really great for me, because I can always do them in 3 and 4 at the same time otherwise one of those things that I just really like, that it all fits together so well. the children, once they're used to the mathematics book, know very well where things are and the symbols are the same everywhere and then you can really work really well with them

Criticism	Differentiation	it is a little difficult, when you have children who are a little weaker
	Lack of practice	things where I just don't have enough exercise material written calculation method has to be firmly established I also take other teaching materials with me, make copies, where that is made even easier to really get to know this automated process
	Complexity	the Zahlenbuch sets quite high expectations when it is concerned with math talk
External Factors	students	because of my children if the cooperation doesn't work the way I want it to
	Covid	math talks completely went down the drain
Role of the workbook		often used for homework

		workbook is simply intended more so that the children can really work independently

Respondent 2

Overarching Themes (through selective coding)	**Open Codes (through substantive coding)**	**Content Units**
Planning	Zahlenbuch based	content of the number book is of course relevant for the majority of schoolchildren [in the past I] always made sure that I worked through the contents of the book, but actually the curriculum was always in the foreground textbook or the respective content is then the companion or the mediator textbook is something that I take as a supplement
	Curriculum based	focus is actually more on the curriculum and the content and not so much on the textbook

		always made sure that I worked through the contents of the book, but actually the curriculum was always in the foreground [at the start of the school year we] create content distribution plans for the respective years the curriculum was always included and that of course on the one hand you have to consider the competence expectations curriculum has always been binding for me, with the planning in the subject mathematics of the process and content-related competencies
	Topic Books	topic books, which, so to speak, lead through the school year successively everyone works on the same topic, but with different materials
	Curriculum alignment	I think it (curriculum) is always well adapted and the Zahlenbuch also adapts well also consider the process-related competencies (Zahlenbuch)

Teacher's Role	Teacher Experience	if you've been teaching for a long time, then maybe you don't look at it that much anymore, but already have it in your head how you want to do it
	Development of Skills	but as a teacher I am also required to say I'm always asked to keep an eye on what else I need, also methodically. I believe that as a teacher I am always challenged to take a good look at what is in it, what is the content of a complex, where do I reduce, where do I expand and for what reasons do I do this respective content-related competence in the foreground and then try to link it with the process-related competencies But then I have to actively guide that and I have to have actively practiced that beforehand

Process-Related Competencies	Textbook and cooperative work forms	also considers the process-related competencies (Zahlenbuch) Zahlenbuch already attaches importance to the fact that content is opened in a complex way and thus this whole area of problem-solving and being creative is included I already have the opportunity to stimulate cooperative learning I've always felt that way with the Zahlenbuch that through the arrangement of the book
	Exchanging ideas	students are initially challenged to say 'How do you calculate?', i.e. 'How do I calculate myself' look what different calculation methods we have and why is which calculation method particularly useful at which point and at which point perhaps not
	Math Congress	Especially in phases of introduction into new content

	Early Development	you have to pave the way for that methodically in the 1 and 2, that children are able to exchange methodically and with a partner has actually always been my goal, from 1 to 4 at some point, so that the children can act more and more independently
Approval	Math Congress Tasks	
	Structure of the Book	actually think it's a good thing if you open it up in a complex and holistic way
Criticism	Differentiation	
	Task Types	that sometimes the task formats on one page change a lot
	Complexity	that a big criticism of the book of numbers is that it is very complex (general criticism)
External Factors	students	
	Covid	
Role of the workbook		the workbook as exercise material

		you can also encourage cooperation with the exercise book, but it's certainly not necessarily designed that way

Respondent 3

Overarching Themes (through selective coding)	**Open Codes (through substantive coding)**	**Content Units**
Planning	Zahlenbuch based	otherwise the Zahlenbuch is very extensive
	Curriculum based	most of our work takes place in advance
	Curriculum alignment	number book mostly covers the math curriculum some things that are very thin, but that's always very thin in all math books so we sat down together in the run-up to the school year, checked whether with the way the topic booklets were designed by

		us with the help of the Zahlenbuch, the curriculum was covered accordingly everything that the Zahlenbuch does not cover enough for us […]we also take the curriculum to hand again we are checking our own work plans to see if they are still up to date for the next curriculum
Teacher's Role	Development of Skills	It's a given, of course that you have to introduce [cooperative work forms] [you cannot say] let's do page 80, it's super great group work, do it yourself you have to be instructed, but each teacher does it individually
Process-Related Competencies	Cooperative work forms	tasks are already marked like this, on tasks that are particularly suitable are already very well chosen I think they're well explained because they're chosen at the right place

	Exchanging ideas	Students realize, in mathematics there is not always just one way, but several ways, you did the math correctly, we did the math correctly, we have the same result, who now has the smarter solution
	Math Congress	when we talk about larger, more extensive tasks explain the results and possible solutions to each other in the hope that either mistakes will be found
Approval	Math Congress Tasks	create introductions to a new topic as group work or in math congresses I think they're well explained because they're chosen at the right place there are exercises in the book that lend themselves the Zahlenbuch also has many possibilities and offers tasks for which you can hold math conferences

Criticisms	Complexity	I get it from colleagues who say, at this point I don't know how to explain the book page Others say: the book doesn't fit, they did that in an unfitting way
Role of the workbook	general	it's basically for deepening, for practicing again, there are separate tasks, but they are primarily to be done individually I can give the task as homework [fitting with the page from the student book]
Additional Resources	Math Congress	one likes to use other exercises that are primarily about the ways of solution Fermi exercises are great

Maģistra darbs „The possibilities of the Zahlenbuch 4 in the development of students' communication skills"

izstrādāts Latvijas Universitātes Pedagoģijas, psiholoģijas un mākslas fakultātē.

Ar savu parakstu apliecinu, ka pētījums veikts patstāvīgi un izmantoti tikai tajā norādītie informācijas avoti.

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ŠIS DARBS PARAKSTĪTS AR DROŠU ELEKTRONISKO PARAKSTU UN SATUR LAIKA ZĪMOGU.