Contribution Academic Article

Title **Multiperspectivity in the Context of Design-Based Research: Theoretical-methodological Considerations to Reading Literacy at the End of Primary School**

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Abstract This article demonstrates the value of multiperspectivity in Design-Based Research. Design principles for the development of the learning environment *Lesen mit Rätseln* are based on scientific and didactic findings on reading literacy. The design was implemented in a primary school with 35 fourth-graders over 10 weeks (SJ 2022/23). Quantitative and qualitative data are analysed to reconstruct reading literacy from multiple perspectives about reading fluency, reading comprehension, reading motivation and self-concept of reading. The objective is to value new evidence of reading literacy at the end of primary school and to evaluate the learning environment *Lesen mit Rätseln.* The paper ends with three scientifically proven and empirically evaluated design principles. These design principles refer to Deci & Ryan (1985) and can be applied to German Didactics. Finally, the design principles indicate advice for practice.

Multiperspectivity in the Context of Design-Based Research: Theoretical-methodological Considerations to Reading Literacy at the End of Primary School

Laura Drepper

1.0 ## Introduction

The research project *Studierende als Lesecoaches* is based on the methodology of Design-Based Research (DBR) and pursues two objectives: the development of a learning environment for reading literacy and to derive new findings for the support of learning processes. The research process follows a cyclical approach and is represented in many models (see e.g. Aigner & Malmberg, 2022; Prediger et al., 2012; McKenney & Reeves, 2019). The focus and number of phases vary in the different models depending on the theoretical basis of research applied. Things in common are the three phases *Analysis & Exploration, Design & Construction* and *Evaluation & Reflection* based on the model of McKenney & Reeves (2019, p. 77). Each cycle is repeated until empirical saturation is reached. Furthermore, new findings on the subject of the research are also an objective (see Dube & Hußmann, 2019, p. 24). In general, the combination of science and practice is important for DBR, i.e. "*dual focus* as a maxime" (Aigner & Malmberg, 2022, p. 31, trans. L.D.). In this understanding, science and practice should be considered as two integrative facets throughout the entire research process (ibid.). One challenge in the combination of science and practice lies in the formulation of design principles with regard to the following two aspects:

> (i) supporting the development of prototypical products (including providing empirical evidence for their effectiveness), and (ii) generating methodological directions for the design and evaluation of such products. In this approach, the scientific contribution (knowledge growth) is seen as equally important as the practical contribution (product improvement) (van den Akker, 1999, p. 4)

The design principles represent both: the empirical evidence for science and the practical contribution for teachers. Therefore, they have different meanings in the phases of the research process: During the analysis, they represent the theoretical research discourse on the learning object. They can also be described as design *assumptions* – comparable to theoretical hypotheses (see Euler, 2017, p. 5; Studer, 2021, p. 6; Raatz, 2015, p. 25). These assumptions set the ground for the definition of the design principles of the learning environment (see

Euler, 2017; Bakker, 2019). A decisive difference between design assumptions and hypotheses lies in the fact that "DBR […] stands less for theory testing, but for theory application and theory building" (Reinmann, 2017, p. 50, trans. L.D.). Design assumptions are more open and flexible than hypotheses, so that the design assumptions and design principles are analyzed, evaluated and reformulated after the design experiment based on the empirical results and theoretical aspects (see also Dube & Prediger, 2017, pp. 9–10). In this article, design experiment means to test the design in practice (see Prediger et al., 2012). The objective is on the one hand to transfer the evidence into practice and on the other hand to contribute to the research discourse (see Bakker, 2019; van den Akker, 2013). In the sense of Euler (2017), design principles act as "a hinge between these focal points" (ibid., p. 2), which also demonstrates the complexity of design principles: While robust and generalizable principles are relevant for science, practice focuses on individual improvement.

One way to solve this complexity may be the use of multiple perspectives when collecting and analyzing data (see Reusser, 2024; Topalović et al., 2023; Reusser & Pauli, 2017; Euler, 2014, pp. 15–18). In method-integrative teaching research, Reusser & Pauli (2013) speak of different "Perspectives of perception" (ibid., p. 310, trans. L.D.) to reconstruct the teaching reality as authentically as possible and to formulate theoretical assumptions for science.

> Further methodological designs are required in order to arrive at reliable statements. Qualitative research approaches (see Proske & Rabenstein 2018) should be strengthened and not only seen as an enrichment of quantitative approaches (see Begrich et al., p. 80), but as part of their foundation. (Reusser, 2024, p. 9, trans. L.D.)

Multiperspectivity is given attention in DBR when analyzing the learning object and design development by making design assumptions with the addition of various theoretical approaches and translating them into design principles for design development. There could be a value in multiple data formats for the design experiment to make the evaluation and reformulation of the design principles suitable for science and practice:

> The central objective of a multi-method design must be the theoretical convergence of qualitative and quantitative research results, i.e. the integration of the research results into a uniform theoretical frame of reference. To this end, it may sometimes be necessary for qualitative and quantitative research results to coincide, and in some cases it will make sense to focus on complementary research results. However, divergent results will also be helpful in many cases (unless they can be attributed to methodological mistakes) by highlighting the weaknesses of the theoretical approaches used. (Kelle, 2007, p. 64, trans. L.D.)

The value of multiperspectivity for DBR will be explained below using the example of the DBR study *Studierende als Lesecoaches.* Based on

Lenord & Kirchgäßner (2022), the course of the research project can be outlined as follows:
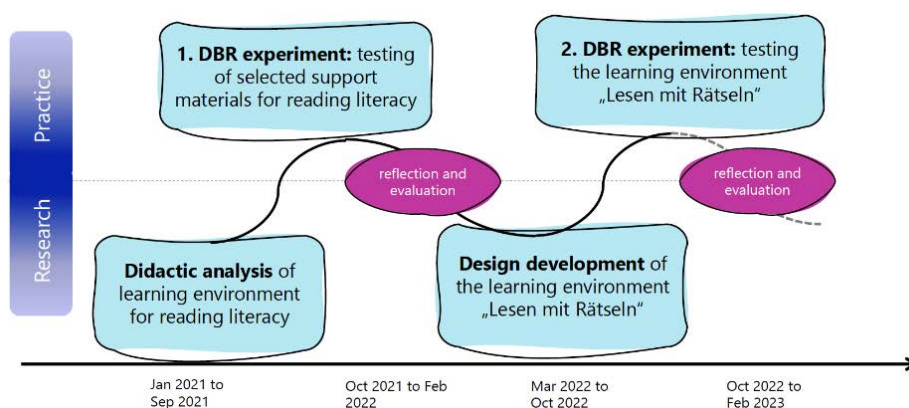

Figure 1: Own illustration based on Lenord & Kirchgäßner (2022)

In the first cycle of the study *Studierende als Lesecoaches*, various support materials for reading have been reviewed, critically analyzed and used for an initial DBR experiment (January 2021 to February 2022). Subsequently, the experiences of the first DBR experiment and multiple theoretical perspectives on reading literacy are combined, i.e. a combination of findings from language acquisition theory, subject-specific science and reading didactics. The learning environment *Lesen mit Rätseln* has been developed in cooperation with the teachers of a primary school in Paderborn, Germany. It has been used in a second DBR experiment by master students who acted as reading coaches. The intention of this article is to demonstrate the value of multiperspectivity in DBR using the design development and design experiment of the learning environment *Lesen mit Rätseln*.

Therefore, the article is divided into six chapters: After the introduction, multiple perspectives on analyzing the learning object (chapter 2), design development (chapter 3) and design experiment (chapter 4) are presented. The research results from the design experiment follow in Chapter 5. The concluding discussion refers to the objective of this article (Chapter 6).

2.0 Multiperspectivity in the Theoretical Analysis of Reading Literacy

The key problem investigated by the DBR study *Studierende als Lesecoaches* is how to foster reading literacy at the end of primary school. The teachers note that many children still need support with reading even at the end of primary school. This finding is in line with the results of national and international studies, according to which 25.4 % of fourth-graders in the IGLU study 2021 and 18.8 % of fourth-graders in the IQB 2021 did not reach the minimum standard in reading by achieving competence level II: "Combination of related information" (Stanat et al. 2022, p. 43, trans. L.D.). According to this, a quarter or fifth of children at the end of primary school fail to meet the following requirements: "To relate information in the text to one another by making simple inferences [and] recognize simple causal relationships,

motives for actions and causes of events " (ibid., trans. L.D.). In the study *Studierende als Lesecoaches*, language acquisition theory, subject-specific and reading didactics perspectives were brought together to solve the key problem and to develop the learning environment *Lesen mit Rätseln*. In terms of language acquisition theory, it can be assumed that due to the general heterogeneity in classes (see Topalović & Drepper, 2019; Löffler & von Albedyhll, 2021), learning environments should create different learning opportunities that can be used by learners individually to reach *their* zone of next development (see Vygotskij, 2002). In terms of language acquisition theory, it is therefore crucial that a learning environment provides children with different, adaptive learning opportunities for learning to read (see Topalović & Settinieri, 2023, pp. 69–74). In this sense, an initial design assumption is: **Learning to read at the end of primary school can be supported by adaptive learning opportunities (DA 1).**

Within the framework of national and international studies (e.g. IGLU, 2021; IQB, 2021), reading is described as the ability to read words, extract information, draw conclusions and reflect critically on content. This definition follows a cognitive understanding of reading, which is differentiated into lower and higher hierarchical processes (see Lenhard, 2019, p. 15; Müller & Richter, 2014; Richter & Christmann, 2009; Schnotz, 2006). According to Müller & Richter (2014), decoding words and local and global coherence building by reading sentences or texts are important for the cognitive dimension of reading. Reading can be seen as the construction of meaning, for which readers integrate information from word, sentence and text level. Regarding the development of cognitive reading skills, research on reading didactics suggests various support options, such as word lexicon training, phonics training, the tandem reading or reading strategy training (see Rosebrock, 2012 for an overview). Reading strategies are often taught and practiced at the end of primary school or in the transition to secondary school (see Philipp & Schilcher, 2012; Rosebrock, 2012; Gold et al., 2010). With regard to children who are not yet able to read at the end of fourth grade, Walter (2020) emphasizes:

> that other skills that support reading comprehension are obviously also developed or need to be developed as part of strategy training. This aspect results from the support that was necessary in this study for the low readers in the areas of word reading and reading fluency. This was the prerequisite for them to be able to engage actively with the detective strategies. (Walter, 2020, p. 340, trans. L.D.)

However, in practice and science there are no multidimensional learning and practice opportunities that teach word reading, reading fluency and reading strategies in an integrative way (see Walter, 2020; Müller et al., 2013; Rosebrock, 2012). A second design assumption is: **Learning to read at the end of primary school can be supported by multidimensional learning opportunities for word reading, reading fluency and reading strategies (DA 2)**.

Furthermore, it is assumed that there is a close connection between cognitive reading skills and the self-concept of reading as well as intrinsic reading motivation (see Mentel et al., 2022; Goy et al., 2017; Möller & Schiefele, 2004). Based on research, learning opportunities that are individually tailored to the child and motivate them to read are important. These opportunities can be characterized by an explicit focus on the needs of the children, cooperative learning, or the ability to experience reading success (see Dehn, 2013; Kruse & Schüler, 2022). In addition, the topic of the text should be an individual interest of the child so that they experience pleasure in the activity of reading (see Mentel et al., 2022; Bertschi-Kaufman & Schneider, 2006, p. 417). The objective is to evoke the joy of reading and an interest in literature so that children are intrinsically motivated to learn to read. A third design assumption is: **Learning to read at the end of primary school can be supported by motivating and individual interest in learning opportunities (DA 3).**

The design *Lesen mit Rätseln* is developed by the three design assumptions listed above. In this sense, "the development of a learning environment is an essential part of the research process and is based [...] on a scientifically sound analysis of the learning object" (Dube & Hußmann, 2017, p. 22, trans. L.D.).

3.0   Multiperspectivity in Developing the Design *Lesen mit Rätseln*

Learning environments that support reading literacy should be motivating and taking into account the children´s interests (GA 3). The teachers involved in the design development emphasized two things: the children should work with literary texts and feel their success as a reader. The self-concept of reading and an active learning attitude should be the focus. It was the intention to create a meaningful, interest-orientated and motivating framework for reading. The content of the learning environment is linked to the fantastic world of *Harry Potter*, because some children requested this topic in the first design experiment. Moreover, Harry Potter is the most-read book for primary school children according to the KIM Study 2020. For this reason, a 66-page self-designed teaching material with seven chapters was developed and used as reading material in the learning environment *Lesen mit Rätseln*. The first design principle is: **Children should learn with topics that address their interests and foster reading motivation.**

From a didactic point of view, the learning environment should be multidimensional by supporting lexical word reading, reading fluency and the teaching of reading strategies (GA 2). Tandem reading proves to be efficient for developing reading fluency (see Gold et al., 2013; Lauer-Schmaltz et al., 2014; Rosebrock et al., 2010). The basic assumption is that a competent other (e.g. a higher-achieving child) provides guidance when reading (semi-)aloud together. The competent other therefore operates as a reading model. However, tandem reading is very demanding, especially for children in the language acquisition process, and is problematic if the corresponding vocabulary is not sufficiently developed (see Lauer-Schmaltz et al., 2014, p. 57; Müller et

al., 2013, p. 132). One possible explanation is provided by cognitive psychological models of reading: If word reading is not yet developed at a lower hierarchical level, there is insufficient capacity for higher hierarchical processes, such as phrasal reading or, more broadly, for comprehension reading. Empirical evidence shows that vocabulary work is particularly effective in promoting lexical word reading (see e.g. Bangel, 2015). From a child's perspective, reading at a word level at the end of primary school also appears to be more motivating compared to initial lessons (see Müller et al., 2013). This is realized in the learning environment *Lesen mit Rätseln* by using a word-picture memory for complex and non-frequent words of the text to be read as an introduction. Semantic information is provided by the picture, grammatical information by the written word and phonological information by reading the word aloud as it is revealed. In addition, some pictures from the memory are repeated in the teaching material and serve as semantic support during reading. A second design principle is therefore: **A picture-word memory should be used to support the expansion of vocabulary.**

Furthermore, the text is left-aligned and structured according to the units of meaning, so that phrased reading at an appropriate reading speed is simplified. The structure of the text thus acts as a "map for the reading process" (Philipp, 2012, p. 41, trans. L.D.) to support reading by extracting meaning. So the third design principle is: **The text should be structured in units of meaning to support appropriate reading fluency.**

In addition, a reading model based on the principle of tandem reading can be helpful in developing reading fluency. Digital support formats, such as digital audio pens from the living environment of the children (see Rechlitz & Lampert, 2016), are considered to have great potential, especially in inclusive and multilingual contexts (see Knopp, 2020; Dube, 2020). Their use does not force literary reception processes, but "allows forms of autonomous, individual reading" (Rothstein, 2015, pp. 458–459, trans. L.D.). Therefore, the entire text is set to audio and the recordings played by an audio pen can serve as a reading model. The fourth design principle is: **A digital device should be used to support an easier understanding of the text and, in addition, to serve as a reading model for appropriate reading fluency, such as a digital audio pen**; with the restriction that no feedback on the reading skills can be given through the pen.

In addition, the digital device is an adaptive learning tool (GA1) that offers children to decide, depending on their learning situation, whether they want to have the text read aloud in full, read it (semi-) aloud or read the text on their own. To additionally enable a high degree of adaptivity (GA 1) when processing the tasks, all texts in the tasks and the material are set to audio. The fifth design principle is: **A digital device should be used as an adaptive learning tool to make it easier to understand the text and tasks, such as a digital audio pen.**

Furthermore, children should be given learning opportunities to use reading strategies to "help them to recognize and remember the most

important information in the text" (Klicpera et al., 2020, p. 107, trans. L.D.). In contrast to reading fluency and vocabulary work, this involves engaging with the content of the text and reading comprehension. In the empirical study with the reading strategy training program *Wir werden Textdetektive* (Gold et al., 2004), children are explicitly taught cognitive and metacognitive reading strategies by applying and practicing various detective methods. Empirical results with children with special educational needs at the end of primary school suggest that the motivation to learn is low when the material is used. Hasselhorn & Gold (2009) explain this in terms of learning psychology as a "motivation valley" (p. 98, trans. L.D.) due to the initial lack of a sense of achievement:

> If such strategies are to be taught at school, it must therefore be expected that considerable motivation problems may arise when learning a new strategy. As the first applications and uses of the new strategy often do not lead to the expected improvements in learning performance, a dry spell, a 'motivation valley', must be overcome in which the use of the strategy is practiced without the hoped-for benefits becoming noticeable at the same time. (ibid., trans. L.D.)

Instead of deductive application tasks, open riddle tasks (see Bormann et al., 2008), which aim to discover reading strategies, could be useful. In combination with playful, hands-on elements, they have a motivating effect and can support interactive collaboration between children (see Richter & Plath, 2012, p. 28), similar to escape room settings that already exist for didactics of biology or mathematics (see Quante, 2022; Veldkamp et al., 2020). The decisive factor is solving complex tasks that require cooperative work with a partner as well as intensive, active engagement with riddles, e.g. puzzles (see ibid.). In this sense, learning to read can be experienced with the function of interaction in a social context. With a view on the development of reading skills, each riddle focuses on one reading strategy, so that a total of seven reading strategies are addressed in the entire teaching material. These reading strategies are based on the reading strategy training program *Wir werden Textdetektive* (see Gold et al., 2004) and cover three cognitive and four metacognitive reading strategies. The reading strategies are integrated into the content of the story and represent the solution to the riddle (e.g. the solution to the riddle can be found by looking it up in a dictionary). A sixth design principle would therefore be: **Open tasks with a riddle character should be used to require cooperative work with a partner, to contribute to a discussion of the content of the text, to discover reading strategies as well as to have a motivating effect.**

4.0   Multiple Methods in the Design Experiment

The adaptive learning environment *Lesen mit Rätseln* was tested in a DBR experiment with 35 fourth-graders in the school year 2022/23 (n=35). The participating fourth-graders were selected by their class teachers, as they assumed that all children had a high need for support

to reading literacy. The teachers focused on word reading, reading fluency and reading comprehension. The results of ELFE II (see Lenhard et al., 2020) before the design experiment confirm the teachers´ assessments: 10 children achieve a T-value of <40 and the results are therefore below average. The results of 24 children are in the lower normal range with a T-value between 40 and 50. For one child, the reading performance in ELFE II is in the upper normal range with a T-value of 57. The DBR experiment was accompanied by 15 master students. In a seminar, the master students received theoretical and methodological training in the selection, analysis and adaptation of digital and analogue learning opportunities for reading literacy. The students were enabled to scientifically penetrate the multiperspective concept of the learning environment and to familiarize themselves with its implementation. The students implemented the learning environment once a week over a period of ten weeks at the school. The learning environment was conducted in defined learning groups, consisting of two and, in one case, of three children. At the beginning of each learning phase, the pupils were introduced to the process of the learning environment, played the picture-word memory, and were then accompanied in a learning phase of 30 minutes while learning with the reading-riddle teaching material. The objective of the empirical testing is to determine the extent to which the learning environment *Lesen mit Rätseln* enables fourth-graders to learn to read. The quality of the learning environment does not lie exclusively in learning outcomes but can also be defined as the "result of the use of the learning environment by the learners" (Brühwiler, 2014, p. 21, trans. L.D.). Therefore, it is interesting to analyse which learning processes are initiated and which aspects of the learning environment the children use to complete the tasks. This means that the target dimensions according to Peters & Rovieró (2017) and Dube & Hußmann (2019) can be recorded at nano level: "the individual specialist learning and development processes of the learners" (see Peters & Rovieró, 2017, p. 27, trans. L.D.) and the "(further) development of specialist learning tasks" (Dube & Hußmann, 2019, p. 21, trans. L.D.). There are two research questions for the design testing in the study *Studierende als Lesecoaches*:

- Which learning processes are initiated?
- How do the children use the learning opportunities (picture-word memory, text structure, audio pen, riddles) to learn to read?

To answer these questions the learning processes of the children were recorded on video during the trial of the learning environment. The methodical access via videography makes it possible to record the handling of the material in small steps and to reconstruct the quality of the learning opportunities. The videographies were transcribed in accordance with GAT2 (see Selting et al., 2009) and were analyzed with MAXQDA. Due to the multidimensional focus of the learning environment on learning to read, additional informal and standardized surveys were conducted on word reading, reading fluency, reading comprehension, reading strategy knowledge, self-concept of reading and

reading motivation. Reading comprehension was used in the form of loud reading sequences and discussions about the content of the text and the standardized ELFE II procedure. In addition, a self-developed survey was used to record reading strategy knowledge. The self-concepts of reading and reading motivation were recorded using a self-developed questionnaire. All surveys were carried out before and after the DBR experiment, which was intended to reconstruct individual learning processes, but not to test the effectiveness of the learning environment:

> In contrast to instructional psychology intervention research, the aim is not to provide general evidence of the learning effectiveness of a design principle as a pre-post comparison of two mean values, but to differentiate general design principles by uncovering specialist causal relationships and reconstructing the effects of the learning environment on individual learning processes. (Dube & Prediger, 2017, p. 5, trans. L.D.)

In addition, after the entire project period, the perspective of the children on the learning environment *Lesen mit Rätseln* was recorded using a self-developed questionnaire and applying interviews with a sub-sample (n=12).

In this article the video recordings are used for the "didactical reconstruction" (Dub & Prediger 2017, p. 5, trans. L.D.) of learning to read. The focus is on reading fluency, reading comprehension, self-concept of reading and reading motivation, so that video excerpts from four groups (1B, 2B, 7B and 8A) are presented as qualitative case studies with a view to these aspects of reading. In line with the "complementarity model of method integration" (Kelle, 2007, p. 61, trans. L.D.), they are supplemented by results from the informal and standardized surveys. For this purpose, the qualitatively collected loud reading sequences with the subsequent reading comprehension questions, the quantitative questionnaire on reading motivation and the self-concept of reading are used. The objective is to demonstrate the value of a multiperspective evaluation for the development of the design and the acquisition of knowledge for learning processes of children in DBR. Based on the research results, the design principles can be concretized or reformulated.

5.0   Research Results: Learning to Read from Multiperspectives

A multiperspective approach in the presentation of results is reflected in the different evaluation methods: Based on the qualitative reconstructions of the learning processes from the videos, results from the informal surveys are presented descriptively by stating mean values (M) and standard deviations (SD) or supplemented by qualitative word analyses.

5.1 Reading Fluency

Regarding the development of reading fluency, the interaction between the two children in support group 8A is striking. The boy Malek reads the text aloud. Reading fluently is still a challenge for him. Then his partner child Kaya interrupts him and gives the following advice:

> **Kaya**: Malek, warte kurz ((Kaya zieht das Rätselheft in die Tischmitte))
> <<Kaya zeigt auf die dritte und vierte Zeile auf Seite 43> hier war ein komma (.) wenn du hier stopp gemacht hättest, könntest du das dann besser lesen wie die hexen und zauberer>

Kaya suggests to his partner Malek to use the comma placement as a reading aid. This illustrates the relevance of the sentence structure and the structure of the text on paper for the automatization process while reading. Comparable to the specific structure of first reading books, the syntax of the text and the semantics prove to be important for learning to read at the end of primary school (see also Stenzel, 2009). The results of the loud reading sequences before and after the DBR experiment support these assumptions. In these sequences, the children read a text with 203 or 204 words out loud. The content of the pre-survey text is only minimally adapted for the post-survey, so that important information on reading comprehension cannot be retained from the first survey (see chapter 5.2).[1] According to the Ravensburg analysis tool *Ratte* (see Wild & Pissarek, n.d.), both texts can be classified as easy for fourth grade with a LIX value of 29.69 (pre-survey) and 30.6 (post-survey). The technical reading time for both texts is approx. 1.8 minutes for the fourth grade and only the word *schillernd* and the names *Leo* and *Theo* can be categorized as rare for the fourth grade based on the childlex corpus. The phonetic reading situation is recorded using an audio device so that reading fluency can be determined retrospectively based on automatization, decoding accuracy, reading speed and prosodic reading. Automation is determined by the number of non-automated words read in the text. The values were collected using two raters. The reliability was determined using Cronbach's alpha and is α=.936 for the pre-survey and α=.955 for the post-survey, meaning that the reliability is particularly high (see Döring & Bortz, 2016, pp. 442–445). Decoding accuracy measures the number of words read without errors, considering self-corrections. Reading speed is determined by the number of words read in the first few minutes. Both components can be clearly determined, so that a guessing procedure was omitted. In prosodic reading, the NAEP scale (Pinnell et al., 1995) is used to determine the level at which the overall text read can be localized (see for a German version: Rosebrock & Nix, 2020; Sappok et al., 2020). The reliability for prosodic reading was also determined by two raters using Cronbach's alpha and is α=.833 for the

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[1] The following words have been replaced in the text: *Löwe Leo* with *Tiger Theo*, *Honig* with *Kakao, Rehe* with *Kühe, Sträucher* with *Grasbüschel*, *Flügel* with *Flossen* and *Ohren* with *Hörner.*

pre-survey and α=.849 for the post-survey, meaning that the reliability is high as well (see Döring & Bortz, 2016, pp. 442–445).

The children do not read an average of 33.4 words automatically in the pre-survey. Only five children can be identified who read less than 20 words non-automatically. On average, the children access around one sixth of the words via grapheme-phoneme correspondences and are not able to read these words automatically. In the post-survey (t2), the number decreases and averages 25.17 words; 13 children read less than 20 words non-automatically. This means that one eighth of the words are not read automatically. If we take a qualitative look at the words not read automatically in the pre- and post-survey, the quantitative data can be explained precisely. For this purpose, the number of times a word was not read automatically by the children was recorded. The words that were not read automatically by more than half of the children (relative proportion >0.5) are listed in a table. With a relative proportion of 1, all children did not read the word automatically:

pre-survey		post-survey	
words (16)	relative share	words (8)	relative share
schillernd	1	schlängelten	0.91
schlängelten	1	schillernd	0.89
freudig	0.83	Grasbüscheln	0.83
glitzernde	0.83	glitzernde	0.83
traumhaft	0.83	strahlenden	0.69
strahlenden	0.77	freudig	0.60
Muffins	0.74	mächtigen	0.57
herrlich	0.74	knabberten	0.54
knabberten	0.69		
Mähne	0.66		
wuchsen	0.66		
Sträuchern	0.64		
geheimnisvoll	0.63		
ergriff	0.63		
mächtigen	0.63		
wehten	0.57		

Table 1: Words were not read automatically by more than half of the children

It is noticeable that the average number of words that are not read automatically in more than half of the cases has halved from the pre- to the post-survey (16 to 8). The words are exclusively content words which increasingly mark a literary context and are used less frequently in everyday conversations (e.g. *schillernd, strahlenden, knabberten*). This finding confirms the importance of literacy experiences for learning to read. The words that were not read automatically by more than half of the children in both the pre- and post-survey are underlined. It can be assumed that they still represent a challenge for the automatization process even after the project work. If we look at the words that reach a relative proportion of >0.5 in the pre-survey but not in the post-survey and therefore pose less of a challenge for the automatization process at the end of the project work (words not underlined in

the pre-survey), it is noticeable that – except for *geheimnisvoll*[2] – all words are two-syllable words. Therefore, linguistic structural complexity appears to be relevant for the automatization process at word level. It is also interesting to note that the words that were frequently not read automatically in both surveys (see post-survey) follow one another in the text (*Schillernd schlängelten* sich zwei riesige Flüsse...*, die an riesigen *Grasbüscheln knabberten*) and/or are separated from the word group by a line break (*glitzernde* [new line] Hörner, *strahlenden* [new line] Blüten). In summary, the case examples and the analyses of the word material from the pre- and post-survey of the loud reading show that the structure of the text and the selection of words can be significant for fluent reading. Accordingly, the design principle can be concretized: *A text should be set in units of meaning and complex, literary content words should not follow each other in clusters to contribute to appropriate reading fluency, especially to foster automatization (DP 1).*

A major challenge for the automatization process is the *lexical route* in word reading, the direct acquisition of a word by assigning meaning to it through a comparison with the mental lexicon. This emphasizes the importance of promoting the linking of semantic, graphemic and phonographic information to a word for children in reading. The following example shows that the children make this connection in the picture-word memory:

> **Lena:** <<zeigt auf die Bildkarte *Animagi* > wie spricht man das aus?>
> **Rahel**: was?
> **Lena**: <<zeigt auf die Bildkarte *Animagi* > das hier>
> **Rahel**: was denn?
> **Lena**: <<zeigt auf die Wortkarte *Animagi* > das erste wort (.) das hier>
> **Rahel**: Animagi

Lena first uses the picture cards (semantic information) and asks about the pronunciation. After the interaction with Rahel, Lena points to the word card and links the graphemic information to it. Rahel then reads out the word *Animagi* and thus provides the phonographic information. During the rest of the puzzle phase, there is also interaction between the two children in which the connection between the picture, the written word and the pronunciation is thematized:

> **Rahel:** <<Rahel zeigt auf die Abbildung von Arnika im Kreuzworträtsel auf Seite 56> aber wie hieß das nochmal?>
> **Lena:** <<Lena zeigt auf das gleiche Bild im Kreuzworträtsel> was (.) das da?
> **Rahel:** ja
> **Lena:** ARniKA

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[2] The word *geheimnisvoll* appears a total of three times in the texts, so that the automatization process of this polysyllabic word may have already improved with repeated reading and the relative proportion is therefore lower.

According to this, the connections between semantic, phonological and graphemic information, as in the picture-word memory, are addressed especially when the children talk about it. Slavin et al. (2009) come to a similar conclusion in a meta-analysis when they emphasize cooperative learning as a decisive feature for learning to read, as it has a positive influence on the development of reading skills in all studies (Slavin et al., 2009, p. 1453). Accordingly, the pictorial elements in the design should become the object of interaction and the design principle should be adapted accordingly: *Meanings* of *picture-word connections should be stimulated in interaction with another child in order to establish the connection of phonographic, semantic and graphemic information to a word (DP 2).*

In addition, the audio pen can be seen as a learning tool to support fluent reading. The videos show that most of the groups have the text read to them using the audio pen, with the finger often being used to follow the text. In these situations, it can also be assumed that the children are reading along while listening. There is no group that does not use the audio pen to read aloud. In many groups, the children switch off the audio pen after a while and start reading themselves, as in the excerpt from group 2B:

> **Veronika:** <<Veronika zeigt auf die eben gelesene Textstelle auf Seite 39> hier. ich kann es jetzt lesen>
> << Veronika geht mit dem Audiostift die Zeilen mit> vor ei:(.)geneng
> **Mila:** eigene Jahre von den merkwundigen
> **Veronika:** würdigen er:eignissen
> **Mila:** betroffen.
> **Veronika:** aus angst mü mich
> **Mila:** wieder (-) unkontrolliert
> **Veronika:** in: eine katze zu verwandeln (.) habe ich mich>
> ((Veronika blättert auf die Doppelseite 40 & 41))
> **Mila:** << Veronika geht mit dem Audiostift die Zeilen mit> in den verboten wald
> **Veronika:** wald
> **Mila:** zurück(.)ge:zo:gen (-) deswegen kann ich dumbledore auch nicht bei der aufklärung der (.) merk:würdigen
> **Erwachsener:** merkwürdigen. genau
> **Mila:** eignisse helfen. danke dass (.) ihr (-) einsprucht ein einspruchtet
> **Erwachsener:** einspringt
> **Veronika:** willst du ähm: es jetzt << Veronika hält den Audiostift hoch> von das hören?>
> **Mila:** keine ahnung nein (-) wenn du willst dann
> ((Veronika tippt mit dem Audiostift auf den Abspielbutton auf Seite 40))
> **Audiostift:** *schon nach kurzer zeit fragte ron*
> *oh man wo treibt sich mcgonagall denn herum?*

The two children take turns to read the text aloud, using the audio pen to follow along in the line (see line 8). After a while, Veronika asks Mila

whether the text should be read aloud again using the audio pen. Although Mila says no, Veronika plays the recording of the audio pen. It is possible that Veronika was already stressed by the short reading phase and therefore uses the audio pen. Therefore, these are mainly short phases in which the children read aloud themselves. The children themselves chose the duration of self-reading, in line with their individual reading skills.

If the results from the phonetic reading sequences before and after the DBR experiment are included, it is interesting to note that the children's prosodic reading after learning with the environment *Lesen mit Rätseln* is on average at level 3 (M=3.0) and is even higher in comparison with the longitudinal study by Sappok et al. (2020), in which prosodic reading in the fourth grade is on average at a level of M=2.8 (SD=0.8). Sappok et al. (2020) attribute the challenges in prosodic reading to a "didactical desideratum" (Sappok et al., 2020, p. 195, trans. L.D.), as teachers focus rarely on prosodic reading in reading lessons. In the learning environment *Lesen mit Rätseln*, the children read a large part of the text prosodically and appropriately using the audio pen. This could also explain why the children achieve a high level in prosodic reading immediately after learning with the environment *Lesen mit Rätseln.* Reading aloud with the audio pen could act as a scaffolding for prosodic reading, which is not offered in this compactness and regularity in the classroom. It is possible that the different voices in relation to gender (male and female) and the disguising of the voices for different characters could have had a positive effect on the children's prosodic reading – comparable to the significantly better results in terms of the growth in basal reading skills of children who were read to by a trained teacher compared to children who were read to by a non-trained teacher (see Belgrad & Schünemann, 2011, p. 164). In summary, the quality of recordings with digital audio pens and the duration of reading aloud could be of relevance for prosodic reading. Accordingly, the design principle can be differentiated: *A digital device (such as an audio pen) that reads the text prosodically appropriately and in high quality should be used to develop prosodic reading (DP 3).*

Moreover, the possibility of self-determination over one's own reading or reading aloud using the audio pen seems particularly motivating. The following could be formulated as a design principle: *A digital device (such as an audio pen) should be used to motivate self-determined reading phases (DP 4).*

5.2 Reading Comprehension

Reading comprehension is a challenge for children, especially when word reading and reading fluency are not yet developed (see Walter, 2020). It is precisely this challenge that Kaya makes explicit in the conversation with the adult when answering the reading comprehension questions following the loud reading sequence of the pre-survey:

> **Erwachsener**: und was fließt eigentlich durch den fluss in dem tal?

Kaya: ich vergesse schnell was ich lese
Erwachsener: ja? meinst du da fließt wasser durch oder war das was anderes?
Kaya: kann sein wasser.
Erwachsener: kann sein wasser? genau
guck mal hier steht.
<<lesend> denn>
Kaya: <<lesend> denn stahlende blüten>
Erwachsener: eine Zeile drunter
<<lesend> denn>
Kaya: <<lesend> durch die flüsse floss kein wasser sondern gelber Ho>
AH!
gelber HONIG!

In response to the text comprehension question of the adult, Kaya directly states that he quickly forgets what he has read (see line 3). He thus makes explicit the challenge of memorizing the content of what he has read while reading aloud. When asked whether it is water, Kaya is also unable to say that it is anything other than water. The adult then points to the passage in the text where the answer to the question can be found. Kaya reads from line 15 onwards and stops when he comes to the crucial word *honey.* He does not finish reading the word *honey*, but directly calls out the answer to the initial question. This means that Kaya can read with comprehension on the second reading thanks to the adult pointing out the crucial passage in the text. This example shows that reading with comprehension can be a challenge for children in fourth grade, especially when reading aloud, and that the support of the adult is necessary for a deeper engagement with the content of the text. A look at the videos from the reading with the learning environment shows that the open tasks with riddle character also encourage the children to engage more deeply with the content of the text:

Veronika: <<Veronika schiebt alle Zettel von der Doppelseite runter> warte ich pack erstmal alles raus (.) ich muss zu die anderen seiten gehen und gucken was man so gesagt hat>
<< Veronika blättert auf die Doppelseite 20 & 21> was hat hermine gesagt?>
<< Veronika fährt mit dem Audiostift Seite 20 ab> DA>
AUCH t(.)ipps von mcgonagall ((liest unverständlich murmelnd weiter))
Mila: <<Mila zeigt mit dem Finger auf das grüne Textfeld auf Seite 20> das ist auch (-)> AH (--) snape
<<Mila hält Veronika einen der grünen Zettel hin> hier (-) das hier>
<<Mila zeigt auf das grüne Textfeld auf Seite 20> snape>
<<Mila zeigt Veronika den grünen Zettel mit dem weißen Strich> und snape>
Veronika: achso jetzt weiß ich wie das geht
((Veronika und Mila blättern gemeinsam auf die Doppelseite 18 & 19))
also ist harry wich:wichtig

Veronika explicitly points out that to solve the task, she first has to go back to the pages she read previously to familiarize herself with the content again. After a short phase in which she reads individual passages of the text again, she then arrives at the correct solution. Group 7B has a similar experience in the fourth chapter, when the two children are looking for the answer to the question of where McGonagall is hanging out:

> **Rahel:** ((Rahel stöhnt und zieht das Rätselbuch zu sich)) lena lena lena ((Rahel blättert auf die Doppelseite 40 & 41)) das war nicht da
> **Lena:** DOCH <<Lena zeigt auf den braunen Textabschnitt auf Seite 40> dumbledore ((liest murmelnd weiter))>
> **Rahel:** <<Rahel blättert im Kapitel hin und her> JA dumbledore hat irgendwas erzählt bei diesem dings (.) hier muss es irgendwo sein bei diesen>
> ((Rahel blättert auf die Doppelseite 38 & 39 und tippt mit dem Audiostift auf den Abspielbutton auf Seite 39))
> **Audiostift:** *hallo ich habe mir schon gedacht dass ihr drei kommt wie ihr gelesen habt waren animagi vor einigen jahren von den merkwürdigen ereignissen betroffen aus angst mich wieder unkontrolliert in eine katze zu verwandeln habe ich mich in den verbotenen wald zurückgezogen*
> **Lena:** ((atmet verstehend auf))
> **Audiostift***: deswegen kann ich dumbledore auch nicht bei der aufklärung der merkwürdigen ereignisse helfen danke dass ihr einspringt*
> **Lena:** <<Lena blättert auf die Doppelseite 38 & 39> ich weiß ich weiß ich WEIß>
> **Rahel:** falsche seite Lena
> **Lena:** ich weiß jetzt (.) sie hat sich aus angst in den verbotenen wald zurückgezogen

Encouraged by the riddle, the children scroll through the chapter and look for a passage in the text that helps them answer the question. Lena also reads some parts for herself, while Rahel presses the audio button and listens to the text again. Lena then finds the relevant passage and can give the answer to the question: They have retreated to the forbidden forest. The riddles in the teaching material encourage the children to turn back to the text, read individual passages again and engage more intensively with the content of the text. It is interesting that Rahel uses the audio pen to read aloud – possibly to counteract difficulties in reading aloud at the expense of reading with comprehension. Therefore, it is particularly important that the children also have the audio pen at their disposal during the riddle phase. Against the background of the empirical results, the design principle can be reformulated accordingly: *Open tasks with a riddle character and an audio pen should be used to contribute to engaging with the content of the text, discovering reading strategies and reading comprehension (DP 5).*

Finally, the video sequences are analyzed in relation to the reading motivation and self-concept of reading. The video analysis shows that some children perceive themselves as competent readers during the reading process, as in this example:

> **Malek:** un:mengen (.) UNmengen>
> **Kaya:** lies mal so, Malek
> **Malek:** UNmengen
> **Kaya:** WARte (.) lies mal leise ich meine lies mal LAUT und DEUTlich (.) SO (.) IN der BIblioTHEK standen hermine harry und ron (.) vor riesige regalen (.) mit un(.)mengen von büchern. (.) es würde tage dauern bis sie (.) das richtige buch gefunden hätten. (.) hermine kannte die bibliothek. <<Kaya schiebt das Rätselbuch wieder zu Malek> so muss du lesen> und nicht ein wort richtig langsam und leise
> **Erwachsener:** ja das ist manchmal gar nicht so einfach weißt du?
> **Kaya:** ja ich hab das gleiche wie Malek vorgelesen und das war einfach

It becomes clear that Kaya, in combination with the other child, falls into an explanatory role and gives advice on reading based on his own experiences. In response to the suggestion of the adults that reading is sometimes not so easy, Kaya explains that reading aloud is perceived by him as easy. However, positive experiences can be valued not only through the perception of being a competent reader during the reading process with another child, but also during riddle work, as the example of group 7B shows:

> **Rahel:** und ich brauch so ein kleines ding ((Rahel nimmt eine Folie mit grüner Markierung, legt sie auf die obere Sprechblase auf Seite 33 und legt sie dann wieder zur Seite))
> **Lena:** HÄ? das geht nicht so rein
> **Rahel:** dann ist das halt nicht richtig ((Rahel schaut sich die anderen Folien an)) wir sind schon aufm guten weg ich weiß
> **Erwachsener:** JA? was macht ihr denn da?
> **Lena:** wir müssen ähm <<Lena zeigt mit dem Finger auf die Folie auf der unteren Sprechblase auf Seite 33> wenn hier was grün ist oder dingsda (-)> heißt das für harry potter (.) für hermine und dings ja (-) und für ron ist ähm der keine ahnung wie der heißt
> << Lena nimmt eine Folie mit blauer Markierung in die Hand> das ist blau>
> << Lena nimmt eine Folie mit grüner Markierung in die Hand> für hermine ist äh grün> und für harry potter ist ähm warte

The passage seems to be of special interest as Rahel points out that they are on the way to solving the riddle ("wir sind schon aufm guten weg"). When asked by the adult, she also correctly explains how they can assign the colours to the right people. During the puzzle phase,

there are frequent joyful exclamations or positive reactions, especially when the riddle has been solved correctly, as in chapter 4, when Lena dances with joy because of the correct answer:

> **Lena:** AH jetzt hab ichs (.) hier steht eine buchstabe
> **Erwachsener:** welcher buchstabe ist das denn?
> **Lena:** das ist ein g
> **Erwachsener**: für?
> **Lena:** gryffindor (.) ich hatte recht
> **Rahel:** stimmt
> **Lena:** ich hatte recht ich hatte recht ich hatte recht ((tanzt))

In addition to the qualitative examples, the results of the self-developed questionnaire from the pre- and post-survey provides an insight into the self-concept of reading in all children. This questionnaire also asks about reading motivation, reading behaviour and reading interests. It contains two open questions, three multiple-choice questions and 23 closed questions. The open questions and the selection questions relate to reading behaviour. The closed questions use a four-point likert scale from *not true at all* to *perfectly right*. Six of these questions relate to the self-concept of reading. Nine questions assess reading motivation (five questions are aimed at intrinsic and four questions at extrinsic reading motivation) and eight questions relate to reading interests.

The wording of the questions is based on the questionnaires by Diederichs (2022) and Valtin et al. (2005). The statements are formulated positively and negatively, but it is pointed out that the changeover is difficult for primary school pupils (see ibid., p. 188). In the study *Studierende als Lesecoaches*, the questions are therefore exclusively formulated in positive and ability-orientated terms (e.g. *I can read better than many other children* instead of *I read less well than many other children in my class*). When interpreting the results, it must be remembered that these are subjective assessments by the children. In line with Goy et al. (2017, p. 150), the mean value is calculated and based on the responses to a self-concept of reading (LeSe) and is categorized as low with a mean value (M) of $M<2$, as medium with a mean value $2 \leq M < 3$ and as high with a mean value $M \geq 3$. The following diagram shows how the proportion of children with a high self-concept of reading increases from the pre- to the post-survey:
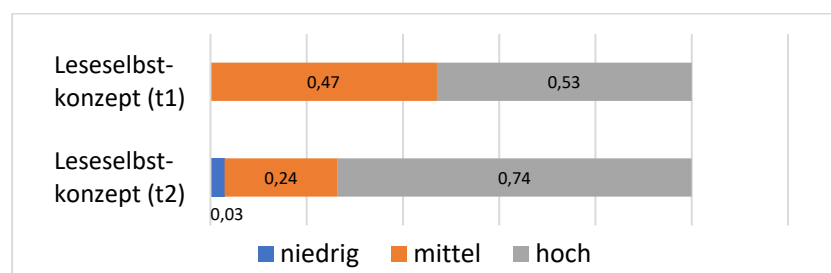

Figure 2: Results on the self-concept of reading for t1 (pre-survey, Sep 2022) and t2 (post-survery, Feb 2023), n=35

In terms of self-concept of reading, the proportion of children with a high self-concept of reading is around 53 % and with a medium self-concept of reading 47 %, which means that children tend to rate themselves worse in terms of reading compared to IGLU. In IGLU 2021, the proportion of children with a high self-concept was 72.7 %, with a medium self-concept 25.2 % and with a low self-concept of reading 2.1 % (see McElvany et al., 2023, p. 137). Interestingly, this distribution is similar to the results from the post-survey in the reading project (high=74 %, medium=23 %, low=3 %). According to this, the children seem to have had positive experiences about their own reading performance over the project period and consider themselves to be better readers. About the design principle, this can be emphasized: *The learning environment should enable children to experience a sense of achievement and their own learning progress when learning to read to contribute to a more positive self-concept of reading (DP 6).*

If we look at the video sequences in terms of reading motivation, the children mainly refer to the content framework. However, negative feelings about the thematic focus on *Harry Potter* are increasingly expressed, as in the two excerpts from groups 1B and 8A:

> **Luis:** mir interessiert eigentlich kein gar nicht harry potter wirklich (.) wieso mach (.) wieso wer hat die harry potter das geschichte ausgesucht?
> […]
> **Luis:** aber (.) warum können wir keine andere geschichte? das ist irgendwie langweilig
> (--) ich mag das mit briefe aber das sonst
>
> **Kaya:** JA (.) wir schaffen das aber (.) wir wollens nicht (-) ich mein (.) ach keiner will das
> ja sag ruhig ((zu Malek))
> **Malek:** ja warum HARRY POTTER?
> **Kaya:** ich schwöre wir wären mit fußball in einen tag fertig (--)

It is interesting that Kaya from group 8A also argues that they would have finished the teaching material in a day, if the topic had been football. Therefore, he assumes that they will not find the solutions to the riddle so quickly due to the topic. This example shows that for the children, a higher level of competence is also associated with the prior content knowledge. Thus, they are not only more motivated, but also perceive themselves as more competent when the learning environment hits a topic in their area of interest. To summarize, the design principle can be extended accordingly: *The objective is to learn with a teaching material which is based on an individually interesting topic to contribute to higher reading motivation (DP 7)*

6.0 Conclusion

The explanations stated above demonstrate what can be achieved by multiperspectivity in the context of DBR by using the example of the study *Studierende als Lesecoaches (LeCo)*. The objective of LeCo is to

develop the adaptive learning environment *Lesen mit Rätseln* and to value new insights into the initiation of learning processes for reading at the end of primary school. In the theoretical analysis, results of scientific, didactic and language acquisition research were brought together so that a multiperspectivity is given in the formulation of design assumptions and design principles for the learning environment *Lesen mit Rätseln*. Multi-data formats and methods (videography, informal loud reading sequences, questionnaires) were used to evaluate the design. When reflecting the data, it was possible to look at reading fluency, reading comprehension, self-concept of reading and reading motivation from multiple perspectives. This multiperspective approach shows that the complexity of the word material and the structuring of the text are of particular importance for the automatic reading process. For reading comprehension, a deeper engagement with the content can be implicitly stimulated through targeted initiation, e.g. in the form of explicit hints from teachers or by using open riddle tasks. In addition, the twofold challenge of reading comprehension and fluent reading in loud reading situations can be seen as demanding for children, which they can also explicitly name (see statements by Kaya). The result is seven evaluated and re-formulated design principles. They will be important for the further development of the design *Lesen mit Rätseln* and the second design experiment in practice:

- A text should be set in units of meaning and complex, literary content words should not follow each other in clusters to contribute to appropriate reading fluency, especially to foster automatization (D1).
- Meanings of picture-word connections should be stimulated in interaction with another child in order to establish the connection of phonographic, semantic and graphemic information to a word (DP 2).
- A digital audio pen that reads the text prosodically appropriately and in high quality should be used to develop prosodic reading (DP 3).
- A digital audio pen should be used to motivate self-determined reading phases (DP 4).
- Open tasks with a riddle character and an audio pen should be used to contribute to engaging with the content of the text, discovering reading strategies and reading comprehension (DP 5).
- The learning environment should enable children to experience a sense of achievement and their own learning progress when learning to read to contribute to a more positive self-concept of reading (DP 6).
- The objective is to learn with a teaching material which is based on an individually interesting topic to contribute to higher reading motivation (DP 7).

In order to further develop the adaptive learning environment *Lesen mit Rätseln,* the most important findings from the theoretical learning object analysis and design development can be combined with the data analysis evaluation: Based on the current state of research in German Didactics, at the end of the primary school, particular attention

should be paid to the aspect of multidimensional learning opportunities (see e.g. Walter, 2020; Schilcher et al., 2022), adaptivity (see Topalović & Settinieri, 2023) and orientation towards the children´s interests (see Möller & Schiefele, 2004; Dehn, 2013). The multiperspective data analysis shows that the audio pen has great potential as an adaptive learning tool for learning to read, as it can be used in a variety of ways by the children according to their individual learning situations: as a reading model to support reading fluency and, in particular, prosodic reading, to engage with the content of the text and, in this sense, for reading comprehension. In addition, learning with the audio pen, open riddle tasks and self-determined learning with the material appear to be motivating, which is shown, for example, when the children start to dance or express exclamations of joy after having reached intermediate steps successfully. Cooperative learning also is of special interest, both to solve the puzzles and to support the individual reading learning process, e.g. when one child explains to the other when they should take a break to read more fluently. This shows the opportunity for children to experience themselves as competent others.

Some design principles have something in common. They relate to one of the three requests of the self-determination theory from Deci & Ryan (1985): autonomy, social integration and competence. In summary, three generalized design principles can be formulated that can be applied to research on learning to read at the end of primary school:

1. The children should be able to learn with the material in a self-determined way and experience a sense of achievement (e.g. by giving instructions to another child) (DP 4, DP 6, DP 7).
2. The task formats should be open and challenging (e.g. through riddles or additional materials) and the children should learn together interactively (DP 2, DP 5).
3. The learning opportunities should be multidimensional (e.g. an audio pen, text structuring, picture-word memory) to adapt to the individual skills and children´s interests (DP 1, DP 3, DP 4, DP 5).

For the methodology of DBR, it is shown that bringing together the different perspectives enables the formulation of design principles that are scientifically robust and therefore compatible with the research discourse. Furthermore, this opens conclusions for teaching referring to empirical results. DBR not only represents a "methodological framework" (Bakker, 2019, p. 7), but also an indication of the link between the reality of teaching and various research perspectives.

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