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Abstract Insights from scientific reading research only partially resonate in Dutch teaching materials for reading comprehension, and hence in the classroom. As an attempt to bridge the gap between science and educational practice, a design-based research was conducted in which four primary school teachers translated four researcher-provided design principles into practice. In two successive design cycles, the teachers designed and implemented lessons on informational text structures, under supervision of two researchers. The aim of the study was to gain insight into the viability of the design principles and into the level of support teachers need in order to become effective co-designers. Based on data from lesson artefacts, teacher logbooks, panel interviews and lesson observations, we found that the teachers experienced several implementation difficulties. These difficulties were partially due to the fact that there was a tension between two design principles, and that one design principle needed refinement. However, in most cases, the implementation difficulties could be explained by teachers' limited pedagogical content knowledge. As a result, the teachers needed a high level of support, especially in text selection and revision. Teachers' beliefs and habits also interfered with the implementation of the design principles, especially when it came to the importance of working with authentic texts, and teachers' views on effective modeling. Our study raises questions about the feasibility of equal participation of researchers and

teachers at the start of a DBR project, but also shows how DBR can successfully contribute to teacher professionalization if researchers provide adequate support throughout the design process.

Keywords Design-based research
research-practice gap
teacher-design team
teacher professionalization
reading instruction
text structure

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Teachers and researchers as co-designers? A design-based research on reading comprehension instruction in primary education

Suzanne Bogaerds-Hazenberg, Jacqueline Evers-Vermeul & Huub van den Bergh

1.0 Introduction

For too long, science and education have been two separate worlds: researchers develop and extend scientific knowledge, while practitioners (teachers, policy-makers, publishers of educational materials) hardly translate this knowledge into their classrooms (Broekkamp & van Hout-Wolters, 2007; Brown, 1992; Ormel, Roblin, McKenney, & Voogt, 2012). Two factors contributing to this research-practice gap are the fact that there is almost no collaboration on equal terms between practitioners and educational researchers, and that practitioners rarely have the time or skills to consult educational research, let alone to translate it into practice. As a result, many parties feel that teaching materials and the curricula of teacher training colleges – and hence teacher knowledge – are seldom research-based (Broekkamp & van Hout-Wolters, 2007). The research-practice gap is also present in the context of reading comprehension instruction. According to the Component Model of Reading Comprehension (CMRC; Aaron, Joshi, Gooden, & Bentum 2008), it is highly problematic when teacher knowledge and text book content is poor, as the classroom environment strongly influences students' acquisition of literacy. Unfortunately, curricular materials for reading follow educational trends and are essentially market driven, while rarely initiating evidence-based principles (Chambliss & Calfee, 1998; Dewitz & Jones, 2013). In addition, teacher knowledge about effective instructional practices for reading instruction appears to be limited (Koenig, 2018), especially when it comes to teaching text structure (Beerwinkle, Wijekumar, Walpole, & Aguis, 2018; Reutzel, Jones, Clark, & Kumar, 2016) and providing high-quality modeling of reading strategies (Okkinga, 2018). However, even if teaching materials are evidence-based, this is no guarantee that teachers successfully implement them. For instance, it has been shown that even with adequate curricular products for text-structure instruction, teachers not always teach as intended (Beerwinkle et al., 2018), possibly because they possess limited knowledge of text structure themselves (Reutzel et al., 2016). One way to bridge the research-practice gap is to have teachers and researchers collaborate in design-based research (Broekkamp & van Hout-Wolters, 2007; Ormel et al., 2012; Vanderlinde & van Braak, 2009). Designing educational materials is – and should be – an important aspect of teachers' work (McKenney, Kali, Markauskaite, & Voogt, 2015). The Dutch government considers it to be one of the major goals for education in the next decades (Schnabel et al., 2016).

Teacher professionalization is often considered to be an important outcome of design-based research (Kafyulilo, Fisser, & Voogt, 2014), because the professional interactions between co-designing teachers and experts can influence teachers' knowledge, perspectives, and self-efficacy (Bell & Gilbert, 1996; Voogt, Westbroek, Handelzalts, Walraven, McKenney, & Pieters, 2011). Specifically, teachers' experiences as co-designers can stimulate them to rethink their understanding of teaching, and restructure their core ideas, beliefs and practices (Bannan-Ritland, 2008). Also, when teachers actively design or modify an intervention, this can have a positive impact on its viability and outcomes, as teachers' involvement can make the intervention more fit into the context (Harn, Parisi, & Stoolmiller, 2013). In design-based research (DBR), teachers and researchers share a responsibility for designing a product and gaining theoretical insight, which shifts researchers' focus towards practical design questions, and teachers' focus towards a more theoretical perspective on the problem (Voogt et al., 2012). For researchers, DBR provides information about the practicality and sustainability of their design principles (McKenney, 2013), as the design is repeatedly tested and (re)adjusted within the complex, authentic context of schools (Brown, 1992), and teachers bring their personal expertise and experiences to the design (Fischer, 2003). For practitioners, DBR participation stimulates professionalization (Kafyulilo et al., 2014). In addition, the resulting curricular products are likely to be sustainable, as the shared development of lesson materials increases teachers' sense of ownership (Cviko, McKenney, & Voogt, 2013; Wikeley, Stoll, Murillo, & Jong, 2005). When teachers are engaged as co-designers, they share a primary role with researchers in the development of innovative practices (Bannan-Ritland, 2008; Englert & Tarrant, 1993). Instead of a traditional top-down model of knowledge dissemination from research to practice, teachers' active involvement and collaboration leads to a two-way flow of information between teachers and researchers, and encourages all parties to negotiate findings (Nutley, Walter, & Davies, 2007; Vanderlinde & van Braak 2009). Such a collaborative partnership on equal terms between teachers and researchers (e.g. Bednarz, Desgagné, Maheux, & Zajc, 2012; Broekkamp, 2007) seems more in accordance with a democratic type of epistemology in which the reflexive capacity of practitioners plays a pivotal role. That is, knowledge is co-constructed in a "reflexive contract" where the theory-driven knowledge, views and experiences of the researchers are mixed with the context-based experiences, knowledge and routines of practitioners in a continuous process of negotiation and reflection (Bednarz et al., 2012). Eventually, this ongoing process of reflection leads not only to new, democratic knowledge, but also to professionalization of teachers. Especially long-term co-design projects create opportunities for teachers to rethink their current practice and integrate research-based practices into their lessons, and to reconsider their beliefs, while it challenges researchers to promote learning and share power with teachers (Bannan-Ritland, 2008). However, the collaboration between teachers and researchers may be different in nature and less on equal terms if the

knowledge gap is wide, and teachers lack the information that is necessary to reflect and build upon during the design process. Although DBR seems a fruitful way to simultaneously increase the quality of curricular materials, professionalize teachers and generate insight in the design principles, this collaboration is also challenging because of the existing research-practice gap. First, researchers are not used to formulating practice-oriented theories that are fit for the unpredictable realities of classrooms, and they may not always be sensitive to teachers' professional development needs (Harn et al., 2013). As a result, the original intent from design-principles might get lost when implemented in the classroom. The implementation can supply great insight into the viability of design principles, and provide input to adapt or elaborate them (Brown, 1992). Second, teachers are often not used to translating research into practice and to collaborate with researchers (Broekkamp et al., 2007). Therefore, various problems may arise. For instance, teachers may have insufficient knowledge to successfully implement a design principle, interpreting it incorrectly. Or they may not always identify which elements of the intervention are flexible, and which are fundamental and should not be altered (Harn et al., 2013). If such problems arise during the DBR, this will generate insight in the level and type of support teachers actually need from researchers to successfully implement design principles. In the current study, we report how four teachers translated a set of researcher-provided design principles into practice, under extensive supervision of the researchers. The study is focused on text-structure instruction in the upper elementary grades in the Netherlands. So far, not many DBR studies have been undertaken in the field of literacy instruction (Anderson & Shattuck, 2012). Only seldom do primary school teachers design their own lesson materials for reading comprehension instruction: they often simply follow the teaching materials with great fidelity (Dewitz & Jones, 2013), even if curricular products are rather weak (Aarnoutse, 1990). Although over the past decades many studies have identified evidence-based practices for the teaching of reading comprehension, these only partially resonate in actual Dutch classroom practice (Bogaerds-Hazenberg, Evers-Vermeul, & den Bergh, 2017). By engaging teachers in a design-based research project, we aimed at designing an intervention for text-structure instruction, and simultaneously gaining more theoretical insight. Also, we intended the teacher design team (TDT) to become more aware of effective practices for the teaching of reading, and to engage more in intelligent decision making on what they should teach (Dewitz & Jones, 2013). Our research questions are:

RQ1: How viable are the design principles in practice (i.e. how did the four teachers implement and adapt the design principles)?

RQ2: What level and type of support do teachers need to successfully translate the design principles into practice?

2.0 Researcher-provided design principles

The teachers were asked to implement four design principles (DPs) that were derived from scientific research (Table 1). These DPs were discussed during the teacher meetings and guided the whole design process. In this section, we discuss their legitimacy.

Table 1. Design principles for teaching text structure.

Design principles	Teacher role	Learning outcome
1. <i>Embed reading instruction in content-area subjects (see 2.1).</i>	Define a clear purpose for reading that is close to the content-area curriculum.	Become more proficient in applying reading strategies in authentic, purposeful content-area reading contexts (transfer).
2. <i>Focus on informative text structures (see 2.2).</i>	Focus students' attention on top-level structure of expository texts and demonstrate how to apply reading strategies to the text structure at hand.	Be able to recognize four expository text structures and apply reading strategies (predicting, questioning and summarizing) in relation to these structures.
3. <i>Balance declarative, procedural and conditional knowledge (see 2.3).</i>	Work towards goals aimed at knowledge about structures and skills in planning, using, and evaluating reading strategies.	Obtain declarative knowledge about text structures, know when and how to make use of this knowledge while reading (self-regulation), thereby also strengthening overall reading comprehension skills.
4. <i>Ensure a gradual release of responsibility with an emphasis on modeling (see 2.4).</i>	Act as a teacher/model first, and then gradually become a coach. Provide opportunities for reflection, collaborative and individual practice.	See DP2 and DP3.

2.1 Embed reading instruction in content-area subjects

When students are aware of the relevance of the learning activity, they are more likely to learn (Goldman, 1997). Reading comprehension instruction can be made relevant and purposeful by embedding it in the content-area classroom (Ogle & Blachowicz, 2002; Read, Reutzel, & Fawson, 2008), as it typically provides an authentic context where students have to read vast amounts of expository texts (Hart & Lee, 2003) in order to learn from text (Chan, Burtis, Scardamalia, & Bereiter, 1992), or use textual information for information-sharing projects (Read et al., 2008). As students are often unfamiliar with the complex structures they encounter, the content-area classroom forms a relevant context for text-structure instruction (Read et al., 2008). Given that the kind of representation readers construct from a text is influenced by readers' purpose in reading (Kintsch & van Dijk, 1978), students should be provided with authentic projects that require them to summarize or recall textual information in speaking or writing tasks (Moss, 2004). During the DBR, the teachers were encouraged to think about engaging projects that could define a clear reading purpose, so that reading would be a means to an end, not an end in itself.

2.2 Focus on informative text structures

According to the Construction-Integration Theory (Kintsch & van Dijk, 1978; Kintsch, 1988), successful readers create a coherent mental representation of the text. That is, they make meaningful connections among different parts of the text, and between the text and their own prior knowledge (van den Broek, Rapp, & Kendeou, 2005). Text structure can facilitate understanding "by helping the reader to organize concepts based on the explicit or implied relationships that are communicated by the text" (Meyer & Ray, 2011:128). This not only facilitates understanding, but also improves the recall of text.

Text structure helps readers to chunk and organize new information, and it also provides mnemonic hooks for learning (Meyer & Freedle, 1984). Various studies and meta-analyses have shown the positive effects of text-structure instruction on comprehension and recall, especially when multiple text structures are taught (Bogaerds-Hazenberg, Evers-Vermeul, & den Bergh, submitted; Hebert, Bohaty, Nelson, & Brown, 2016; Pyle et al., 2017). In the US, educators have strongly recommended text-structure instruction, even starting from kindergarten (Shahanan et al., 2010). Although Dutch nation-wide standards state that sixth graders must be able to understand various informational texts (Commissie-Meijerink, 2009), Dutch lesson materials pay little attention to text structure (Bogaerds-Hazenberg et al., 2017). We encouraged the TDT to develop lessons about cause/effect, problem/solution, compare/contrast, and the chronological structure, because these are common in content-area texts (Pyle et al., 2017), and may be just within the zone of proximal development of the target group (Meyer, Wijekumar, & Lei, 2018). The TDT was specifically asked to a) focus their text-structure instruction on the characteristics of each structure (central questions, cue words), and b) teach how to apply reading strategies such as predicting, questioning and summarizing specific to the text structure at hand. As teachers often have difficulties with recognizing text structures (Beerwinkle et al., 2018; Reutzler et al., 2016), the TDT received explicit instruction on the four structures.

2.3 **Balance declarative, procedural, and conditional knowledge**

Teaching reading strategies is a very promising approach for improving students' reading comprehension (Palinscar & Brown, 1984; Yuill & Oakhill, 1988). However, students will only become strategic readers if they are able to purposefully apply these strategies, that is, in a flexible, context-sensitive way. Therefore, students need declarative, procedural and conditional knowledge: they need to know a) which strategies can be applied, b) how to carry out these strategies as effective as possible, and c) when and why certain strategies are useful in various types of texts (Duffy, 2002; Duke & Pearson, 2002; Paris, Lipson, & Wixson, 1983; Kostons, Donker, & Opdenakker, 2009). Knowing when and why certain reading strategies can be used – conditional knowledge – is crucial for a satisfactory level of self-regulated strategy use (Malone & Mastropieri, 1992). Text structure can provide a useful framework to develop conditional knowledge, thus helping students to apply strategies in a more context-sensitive way (Goldman, 1997). Therefore, we asked the TDT to provide a balance in declarative, procedural and conditional lesson content.

2.4 **Gradual Release of Responsibility with emphasis on modeling**

The TDT was encouraged to pace instructional activities according to the Gradual Release of Responsibility Model (Fisher & Frey, 2013). In this instructional model, the responsibility for the learning activities first lies with the teacher, and is then gradually transferred to the students, which is often translated into different lesson phases: explicit instruction and teacher modeling, guided practice, collaborative activities and individual practice.

As previous research has shown that many teachers struggle with modeling, and that current teaching materials provide little guidance (Bogaerds-Hazenbergh et al., 2017), we asked teachers to put emphasis on modeling in their instruction. We also recommended that after modeling, teachers and students would discuss what just happened, because an active evaluation after modeling has a positive impact on student outcomes (Braaksma, Rijlaarsdam, & Van den Bergh, 2002). Specifically, students might benefit from comparing models (Gentner & Namy, 1999), and from looking not only at mastery models (i.e. very competent models who make no mistakes and are self-confident in task execution), but also at coping models: less competent models who show their errors and hesitations first, but gradually improve their performance (Braaksma et al., 2002). We also instructed the teachers about the five essential conditions for effective collaborative learning: positive interdependence, promotive interaction, individual accountability, group processing, and social skills (Johnson & Johnson, 1984). We discussed two types of collaborative learning: reciprocal peer tutoring (Palinscar & Brown, 1984) and jigsaw activities (Aronson, 1973). In reciprocal peer tutoring, students practice reading strategies in pairs while taking turns as tutee (i.e., read and think aloud) and tutor (i.e., provide support, ask clarification questions) (Okkinga, 2018; Palinscar & Brown, 1984). In the jigsaw cooperative learning structure (Aronson, 1973), the material to be read is split into different pieces that are divided among expert groups. Within these expert groups, students try to make sense of their piece of information (Doyumus, 2007). Then, mixed groups are formed in which each expert student teaches their part to the other group members. This exchange is crucial for the completion of a joint product, just as in a jigsaw each piece is needed (Colosi & Zales, 1998).

3.0 Methods

3.1 Participants

Over the course of one year, a team of four elementary school teachers developed a lesson series for reading comprehension in collaboration with two researchers. The teachers taught at four Dutch elementary schools and had on average 19.5 years of teaching experience ($SD = 6.8$). They were purposefully sampled and invited to participate, because they were all eager to change their reading instruction. Two teachers taught in grade 6 and already had some experience with lesson design. The other two teachers taught in grades 4 and 5, and had not developed lessons themselves before. They followed a teacher manual with a strong focus on reading strategies and individual practice. As the design principles were already determined by the researchers, there was some asymmetry in the roles of teachers and researchers at the start of the project. Although co-design would typically imply a reflexive contract in which researchers and teachers co-construct knowledge based on theory, experiences in practice and continuous reflection (Bednarz et al., 2012), our project gave the primary responsibility to researchers: they designed the four DPs and supervised the teachers during the design process. The first author participat-

ed as moderator, observant and primary supervisor to teachers; the second author acted as secondary supervisor and was present during the four teacher meetings. However, the researchers paid close attention to teachers' reactions to the research problem and DPs (see 3.2), as we wanted teachers to remain motivated throughout the project and to consider themselves problem owner as well (e.g., Ejersbo, Engelhardt, & Froliunde, 2008). The researchers were also open to teacher feedback, during meetings or mail contact in between sessions.

3.2 Design process

Table 2 provides an overview of the design cycles and the data sources. Teachers were invited to two meetings before they started the lesson development. During the kick-off meeting, teachers and researchers exchanged ideas about the problems that characterize current practice in comprehension instruction (e.g., a lack of integration of reading instruction and other subjects, an overkill of strategies and individual question answering, no attention to structures). Although the researchers took a primary role in defining the research problem, the teachers could easily relate to this problem and seemed eager to act as co-designers. In order to prepare teachers to their task as co-designers, they were introduced to the four informational text structures, the design principles, and their legitimacy. In preparation of the second meeting, teachers were asked to select or write a suitable informational text and to develop a try-out lesson. During the second meeting, the teachers reflected on these try-out lessons and discussed the design principles again. The teacher meetings were planned in such a way that teachers and researchers first had the time to discuss practical issues, and then focused more on the theoretical ideas and viability of the DPs. We expected teachers to gradually deepen their understanding of teaching text structure, and become more aware of effective practices by immersion in this design project. Also, we expected them to adapt their beliefs and less effective practices in the ongoing process of adaptation and reflection during the design cycles (see Bannan-Ritland, 2008), especially because many insights were quite different from current practice. During the first design cycle, each teacher developed five lessons on reading comprehension and implemented them in their own classroom. Teachers reflected on each lesson in a logbook and received feedback on their artefacts from the principal investigator. Based on this first trial and feedback, teachers slightly adapted their lessons. Then, the researcher collected all lessons and finalized them for the second phase. During the second design cycle, in meeting 3, the teachers first exchanged experiences with the lesson development (i.e., text selection, choice of lesson goals, pedagogy) and discussed their ideas for refining the content and pedagogy of the materials. Then, they exchanged their revised lessons, taught five revised lessons of another teacher, and kept a logbook. They were also observed during two lessons. During the fourth meeting, the teachers reflected on the main design issues and their experiences.

3.3 Data collection

In order to analyze how teachers implemented the DPs, various types of qualitative data were collected (Table 2). Teachers were asked to comment in their logbooks on the development and implementation of each lesson. They reported on the time spent on lesson development and the duration of the lesson, and rated on a five-point Likert scale their satisfaction with texts, pacing of activities, content, student and teacher activities.

Table 2. Overview of lesson development, specifying the different roles and data sources.

Design Cycle 1		Design Cycle 2		
Meeting 1 & 2	Try-out 1	Meeting 3	Try-out 2	Meeting 4
<i>Teachers</i> 1: Receive information about text structure and DPs. 2: Apply DPs and discuss try-out design (2).	<i>Teachers</i> Develop, test and revise first design.	<i>Teachers</i> Reflect on first design, discuss DPs and exchange lessons.	<i>Teachers</i> Test, revise and reflect on second design.	<i>Teachers</i> Reflect on second design and discuss DPs.
<i>Researchers</i> Discuss legitimacy of DPs, provide feedback on try-out design.	<i>Researchers</i> Provide feedback for revisions of first design. Support and finalize second design.	<i>Researchers</i> Moderate discussion and elaborate DPs.	<i>Researchers</i> Lesson observations.	<i>Researchers</i> Moderate discussion.
<i>Data</i> -	<i>Data</i> Artefacts and feedback, logbooks.	<i>Data</i> Panel interview.	<i>Data</i> Artefacts and feedback, logbooks, observations.	<i>Data</i> Panel interview.

In addition, they had to mention their planned revisions for a second design. The logbook for design 2 also contained questions about the completeness and clarity of the manual. During the second design cycle, the principal investigator also observed and videotaped two lessons per teacher. Notes were taken about the duration of each lesson phase, the implementation of pedagogical activities such as modeling and collaborative practice, and student involvement per lesson phase. Teachers shared the first draft and the revised versions of each lesson with the researcher. These artefacts gave insight in the series of adaptations the teachers made during the DBR. These adaptations and other issues relating to the design principles were discussed during the third and fourth teacher meeting, in which two semi-structured panel interviews were held. In particular, the questions addressed the 1) text selection procedure, 2) choice of lesson goals, 3) satisfaction with researcher feedback, 4) pedagogical choices (timing and type of activities), and 5) perceived usefulness of the DPs. In order to obtain insight into the viability of the design principles (RQ1), the researchers examined all artefacts and paid special attention to the ways in which teachers operationalized the DPs in their lesson design, making note of missing elements and marking everything that deviated from the DPs. Additional information in relation to RQ1 was obtained from logbook data, which revealed teachers' views on the viability of the DPs. During the panel interviews teachers were asked to elaborate on their views. The question about the support teachers need (RQ2) was mainly answered on the basis of data from the teacher meetings and

panel interviews. The scripts of the panel interviews were reread in order to make a list of teachers' uncertainties and questions relative to the design. The support question was also answered on the basis of a continuous process of reflection; the researchers reflected on the teachers' progress by comparing the quality of the first and second design, taking into account the support and extra explanations they had to provide during the process.

4.0 Results

In section 4.1, we will first discuss how the four design principles were implemented in both lesson designs. In section 4.2, we will describe what difficulties the teachers experienced while implementing the design principles, and the ways in which the researchers provided support during the iterative design process.

4.1 Implementation

Overall, teachers were satisfied with both designs. During the first design cycle, the TDT developed 20 lessons about four informational text structures: compare/contrast, cause/effect, chronology and problem/solution. In the second cycle, lessons were adapted and tested again, with major text revisions and, to a lesser extent, revisions in the content of the instruction. DP1 required teachers to embed reading comprehension instruction in content-area subjects. This principle was implemented as a guideline for text selection: teachers chose texts close to the content-area curriculum. The teachers still kept teaching content-area subjects and reading at different moments. In the first design, seven texts were unrelated to content-area subjects, but were selected because of a clear text structure (e.g., a recipe). In the second design, most of these texts were replaced. DP2 required teachers to focus their instruction and use of reading strategies on text structure. The teachers were satisfied with DP2 and considered text structure a helpful tool for students to get the gist of a text and integrate information at a higher level. "We always try to teach them that they must be aware of how the paragraph fits within the whole text, and how that fits with the title. But by looking at the text from the perspective of text structure, I think my students learned more easily how to summarize at the text level and go beyond paragraphs." In addition, two teachers reported that, to their surprise, their students spontaneously applied their knowledge in other lessons. However, the teachers experienced a tension between DP1 and DP2: because they had difficulties finding and selecting well-structured content-area texts, they ended up with many poorly structured texts, which made text-structure instruction difficult. As texts were fundamentally revised in design 2, the number of texts with mixed structures were reduced. DP3 required teachers to formulate declarative, procedural and conditional lesson goals focused on reading. However, in 55 % of the lessons of the first design, conditional goals were lacking. Instead, teachers often also formulated declarative content-related lesson goals: goals focusing on the subject of the text, not on reading outcomes. After additional feedback from the researchers, the lesson goals in the second design were refined, or eliminated if they were not focused on reading

comprehension. When reflecting on DP3, the teachers mentioned that formulating lesson goals gave them more ownership and made them more reflective about their lessons. “When designing the lessons you really start to focus on those lesson goals. It makes you think: why would I actually do this? Because with those text books, well, you just simply recite the lessons.” Most lessons in the first design cycle contained the pedagogical elements that one would expect based on DP4 (i.e., explicit instruction, guided practice, collaborative and individual activities). We analyzed the viability of DP4 by examining the realization of these pedagogical elements and the time allocated to each phase in both designs. Table 3 summarizes how often each lesson phase was realized, and what time was allocated to it in the teacher manual. Teachers emphasized collaborative learning, guided practice, and modeling. They developed full scripts and bullet-like lists with comments as a guideline for teacher modeling. Although the researchers had strongly recommended an explicit moment of reflection after modeling, this was realized in only 60 % of the lessons in the first design. The teachers were eager to incorporate collaborative activities, in particular the jigsaw activities, and came up with many more types of student activities (e.g., games) than the researchers had suggested. By contrast, in 35 % of the lessons, they did not incorporate individual activities. In the second design, more time was allocated to explicit instruction, and more lessons contained a reflection after modeling. Complex collaborative activities were replaced, and extra individual tasks were included, so that the majority of lessons in design 2 realized a full gradual release of responsibility from the teacher to the individual student, as intended by DP4.

Table 3. Scheduled time per lesson phase in both design cycles.

Pedagogical approach	<i>Design Cycle 1</i>		<i>Design Cycle 2</i>	
	Prescribed in lessons (%)	Allocated time (min)	Prescribed in lessons (%)	Allocated time (min)
Explicit instruction	80	4.4 (2.9)	90	6.6 (4.8)
Modeling	90	5.1 (2.8)	90	5.3 (2.5)
Reflection	60	1.6 (2.0)	85	3.8 (2.4)
Guided practice	100	9.3 (3.9)	100	10.0 (4.7)
Collaborative learning	95	13.8 (8.6)	95	11.3 (8.0)
Individual practice	65	4.1 (3.5)	90	6.6 (4.1)

4.2 Challenges in the implementation of the design principles

Table 4 summarizes the issues that were encountered during the implementation of the DPs, and the data sources in which these were found. In the following subsections, we will discuss per DP what difficulties the teachers experienced, and the ways in which the researchers provided support and helped resolve these issues during the iterative design process.

4.2.1 Unclear structure of content-area texts (DP1)

During the first design cycle, but also in the third teacher meeting, all teachers complained that it was almost impossible to find appropriate texts in content-area text books, as according to the teachers these texts often contained narrative elements and lacked a clear structure. “Soon I discovered that most texts did not have a clear, for students recognizable, structure.” As a result, selecting the right text was a time-consuming task that

sometimes demotivated the teachers, especially when they had to revise the text thoroughly in order to be able to use it for text-structure instruction. “I even developed lessons during my days off, because selecting texts was very time consuming.” After the first try-out, the teachers found out that selecting a text with a clear structure, or revising a text to the same end, was crucial for success. Two teachers recognized their lack of knowledge and explicitly asked the researchers to help or take over text revision for the second design (see 4.2.3), except for two teachers who kept using authentic texts they hardly revised (see 4.2.2). However, at several occasions, the latter wrote in their logbooks how this negatively affected their text-structure instruction: “The text was so complex that we were not able to make and discuss the graphic organizer.” By contrast, in lessons with better structured and less complex texts, teachers were able to provide more text-structure instruction. One teacher reported that once a text is right, the lesson will be right, as “it suddenly becomes easy to see what you can teach in a lesson.”

Table 4. Issues related to the implementation of each design principle.

Design principle	Issues	Data source				Quote/Example
		A	L	P	O	
1. Embed reading instruction in content-area subjects.	Unclear structure of content-area texts.	✓	✓	✓	✓	I searched content area books first, but soon I discovered it would be time consuming to work with those texts. They were not suitable at all: texts were too simple, or it was narrative-like. Summarizing this text with a Venn diagram was like flogging a dead horse. The texts had to match students' interests and level, and also contain enough leads to teach structure. That was challenging. I had to explain a lot because of the text difficulty. I think the text might have been too complex to also discuss structures. When I had a chronological text, I looked which signaling words the text already contained, (...) and I added extra signaling words. Look at the picture. What possible causes of drought can you think of? (No structure-based prediction)
2. Focus on informative text structures.	Difficult to revise text structure	✓		✓		Teachers formulate lesson goals focused on content. Difficulties with formulating conditional knowledge goals, and no alignment in lesson content.
3. Balance declarative, procedural, and conditional knowledge.	Reading strategies not tailored to structure	✓		✓	✓	Teachers formulate lesson goals focused on content. Difficulties with formulating conditional knowledge goals, and no alignment in lesson content.
4. Ensure a gradual release of responsibility with an emphasis on modeling.	Content-related lesson goals Little attention for conditional lesson goals	✓	✓	✓	✓	They only provide scripts for teacher modeling (mastery model, no coping model). I did not do the game with my class, because I actually didn't understand it myself. Teachers ask students to work together on individual tasks.
	Modeling: no coping model or student modeling	✓	✓	✓	✓	
	Collaborative activities: individual accountability and poor transferability	✓	✓	✓	✓	
	Few opportunities for individual practice	✓		✓	✓	

Note: Data source is checked if evidence for implementation issue is found in A: artefacts, L: logbooks, P: panel interview, O: observations.

4.2.2 Competing selection criteria (DP1)

The teachers experienced a tension between criteria for selecting texts, which might have been triggered by a tension between the DP1 and DP2. On the one hand, teachers wanted to select authentic texts within the content-area curriculum (DP1), on the other hand, they aimed using at well-structured text (DP2). But the teachers had other selection criteria as well, such as appropriate sentence length and an interesting topic (especially for boys) that matches students' prior knowledge. Although a clear structure was expected to be the main criterion, teachers gave priority to a challenging topic. However, when the teachers discussed their experiences with the first lesson try-out, they became more aware of the fact that an adequate structure was a non-negligible selection criterion. Two teachers explicitly chose to prioritize DP1: they selected authentic texts and made few revisions, as they were used to do at their schools. They simply "looked which text structure could fit best." However, fitting in a structure was no easy task: adding signaling words did not fundamentally improve the structure of the text. Even in the second design, they kept using authentic, hardly revised texts. The lesson observations revealed that this happened at the expense of text-structure instruction: they kept focusing their instruction on the topic of the text (i.e., activating prior knowledge, extensive class discussions about ideas in the text) and on complex vocabulary (i.e. explaining difficult words). As a result, little time was left for text-structure instruction. They also struggled with exercises on text structure, such as summarizing text with graphic organizers. During the second design cycle, they gradually became more critical about their own criteria and beliefs. One teacher reported on one of the final lessons: "I had to explain a lot because of the conceptual difficulty of the text. Maybe the text is too complex to talk about text structure as well." During the fourth meeting, her colleague commented that using a Venn diagram to summarize a complex, authentic text felt like "flogging a dead horse", and that including "a more stereotypically structured text" might have been a better choice.

4.2.3 Difficult to revise text structure (DP2)

As many content-area texts were not well structured, the structure of most texts needed to be revised. The teachers did not realize this at first: only once, a teacher proposed in her logbook that the text should be drastically edited, but she did not do this because she felt that "it would be too time consuming and complicated to change the top-level structure." The researchers asked the teachers during the first design cycle to critically examine the texts, and to revise the top-level structure in order to make it more salient. Teachers indicated in their logbooks and in the panel interviews that this text revision formed a major obstacle. Their knowledge about revising text structure appeared to be insufficient. Although the researchers expected the teachers to reorder ideas in the text in order to clarify the top-level structure of the text, teachers only made local revisions, by adding signaling words and simplifying vocabulary, except for two teachers who attached great value to text authenticity: they underscored and explained

difficult vocabulary in the margins. None of the teachers reordered information beyond the sentence level, so that the top-level structure was not essentially clarified. As a result, the majority of texts in the first design cycle lacked a clear top-level structure: they either had a mixed structure (i.e., different structure within paragraphs without a clear overarching text structure), or a simple list structure with some causal relationships. Teachers' difficulties with text revision also appeared to be due to their difficulties with recognizing text structure in the first place. Because of their strong focus on local text structure markers (i.e., signaling words), they did not always successfully identify the top-level structure. For instance, a teacher treated a text with many dates as a chronological structure, whereas it actually focused on causes and effects of European collaboration. Because of teachers' difficulties, the researchers themselves revised the texts for the second design by reordering information at the paragraph level, and by simplifying complex vocabulary. These changes were discussed with the teachers during the third meeting. The logbooks show that teachers felt happier with the revised texts.

4.2.4 Reading strategies not tailored to structure (DP2)

During the first design cycle, text-structure instruction seemed to be treated as an addition to business-as-usual: teachers kept teaching global reading strategies (e.g., making predictions based on vocabulary or pictures, instead of based on expectations about the structure), and gave additional text-structure instruction. The lesson artefacts showed a lack of integration: teachers were not aware of the fact that they could apply reading strategies such as predicting and questioning specific to the text structure at hand. Only when it came to summarizing, teachers had no difficulties integrating this reading strategy with text structure: they provided graphic organizers specific to each structure to help their students summarize. As teachers kept providing both global reading strategies and text-structure instruction, and hardly integrated both, there seemed to be an overkill of information in each lesson. It seemed that DP2 should state more clearly that a focus on text structure has implications for the use of all reading strategies, in order to prevent an overkill of different angles on the text. In the first design, the teachers also overemphasized the signaling words that characterized each structure, possibly because signaling words form a familiar topic for the teachers, and can easily be identified at the sentence level, without having to focus on the top-level structure that was often rather unclear in the texts of the first design. The teachers were not very satisfied with this focus on signaling words: they were afraid it was monotonous, and that it could become a simple trick: "You must be careful; the children might simply underline signaling words, and then it becomes a trick they simply apply without thinking. You don't want that to happen." Therefore, during the third meeting, the researchers elaborated DP2 in order to clarify that a focus on text structure meant that all strategy use should be tailored to the text structure at hand. The researchers explained again how reading strategies can be

applied specific to the structure at hand, and encouraged teachers to incorporate a larger variety of reading strategies – and not focus on signaling words in each lesson. The researchers showed in rewritten modeling scripts how teachers could make better predictions about the content of the next paragraph based on text structure, and the kind of questions they could ask. The clarification of DP2 and additional support with concrete examples led to more integration in the second design cycle: teachers more often made predictions about the form and content of the text based on text structure, and varied more in their strategy use.

4.2.5 Content-related lesson goals (DP3)

Teachers were tempted to work towards content-related goals: for some teachers, understanding the meaning of the whole text was more important than acquiring new knowledge about text structure. For instance, two teachers formulated goals such as “After this lesson, students will know how the lives of Sherpa’s changed over the past decades.” Even if lesson goals were focused on reading goals, the teachers did not always match their instruction and activities to these reading-related lesson goals; they still strongly emphasized the content and vocabulary of the text, and much less the text structure at hand, even after researchers’ feedback on the first design. Therefore, during the third meeting, it was stressed why it was important to focus on reading goals and put less emphasis on content-related goals. However, even during the second design cycle, the teachers kept emphasizing the content of the text as well, which in some lessons led to a lack of alignment between the formulated reading goals and the actual focus of the lesson. It seemed that teachers’ beliefs interfered with the implementation of DP3, and that teachers were not always certain about the ways in which they could embed reading instruction in content-area subjects without losing focus on reading-related goals.

4.2.6 Operationalization of conditional knowledge (DP3)

The artefacts show that the teachers had difficulties formulating conditional knowledge lesson goals (when and why lesson goal), and often did not design activities that could help students plan and evaluate their reading approach more consciously. Instead, instruction on conditional knowledge consisted of simply telling students at the end of the lesson when and why a strategy would be useful. It seemed that the concept of conditional knowledge was too unfamiliar for teachers to work with. Therefore, during the third meeting, the researchers provided concrete examples of activities that could be explored as a means to further develop conditional knowledge, for instance by having students think about a useful reading approach in specific scenarios (e.g., Pete wants to summarize a text about the differences between viruses and bacteria. What kind of summary would you recommend, and why?). Teachers were enthusiastic about these additional exercises and gladly incorporated them into their lessons of the second design cycle.

4.2.7 **No student modeling or coping models (DP4)**

The teachers did not apply all guidelines for modeling that were discussed during the kick-off meetings. In particular, teachers were encouraged to include both teacher modeling and peer modeling, but in almost all lessons from the first design cycle, only teachers themselves acted as model. Although teachers were also asked to sometimes act as a coping model, all teachers only acted as mastery models. As the researchers thought this might be due to a lack of knowledge, they encouraged teachers during the third meeting to examine the modeling scripts to see whether they could make some 'mistakes' in modeling and repair them while thinking aloud, such that students could gain more insight into why strategies do or do not work in specific reading situations. Unfortunately, this did not result in important changes in the next design. Therefore, after the fourth meeting, in collaboration with one teacher, six video clips were produced with peer modeling in which the reading processes of both weaker and stronger readers were demonstrated.

4.2.8 **Issues related to design of collaborative activities (DP4)**

Overall, teachers were satisfied with the collaborative learning activities, especially with jigsaw activities. However, in these jigsaw activities, the teachers did not always make the final group assignment relevant to all students. This issue did not come up during the first design cycle, but only became apparent during lesson observations in the second design cycle. That is, as the final exercise often consisted of students simply exchanging information about their part of the text without an additional task, their peers did not always feel the need to listen carefully during this exchange. Therefore, after the fourth meeting, the researchers made sure that the final phase of jigsaw activities had a clear individual component (e.g., an individual writing task for which they needed information from their peers) so that students had to pay attention during information exchange. Another issue concerned the transferability of the collaborative activities: the more creative the classroom activity, the more difficult other teachers found it to carry them out in their own class. For instance, one teacher invented a game on the effects of import tax on trade. After the first try-out, she wrote that her students enjoyed the collaborative activity. However, when it was tested in the second design cycle, her colleague wrote: "I skipped the game, because I actually didn't understand it myself." Therefore, after the fourth meeting, two relatively complex activities were changed into more familiar collaborative activities.

4.2.9 **Few opportunities for individual practice (DP4)**

Although the researchers emphasized that collaborative activities should be followed by individual activities, the teachers left hardly any room for individual practice. During the third and fourth meeting, the interpretation of DP4 was discussed; teachers wondered if all phases of the instructional model should be realized in each lesson, or if these should be distributed over various lessons. Lesson observations also revealed that even if there was time for individual activities, teachers still assigned it as a group

task. The issue was partially resolved by strengthening the individual component of the jigsaw activities (see 4.2.8) and adding individual activities aimed at conditional knowledge (see 4.2.6).

5.0 Conclusion

5.1 Viability of design principles (RQ1)

Our design-based research provides insight into the viability of the design principles. Overall, the teachers seemed satisfied with the DPs. As reported in previous DBR studies (Cviko et al., 2013; Wikeley et al., 2005), the teachers reported to be more conscious about what they actually wanted their students to learn. Especially DP3 that required teachers to formulate lesson goals was highly appreciated; teachers experienced ownership over their lessons and became more focused on learning outcomes. It turned out that not all DPs were viable in their current form, and needed some elaboration. In DP2, the ‘focus on informative text structures’ did not state clear enough that it required teachers to demonstrate and apply reading strategies specific to the text structure at hand. In order to increase the viability of DP2, it seems wise to both emphasize this, and to provide more guidance in which strategies should be taught to guarantee a sufficient level of variation in strategy use. DP4 raised the question whether all lesson phases that are described in the Gradual Release of Responsibility model (Fisher & Frey, 2008) should be part of each lesson, or if and how they should be distributed over different lessons. In addition, the simultaneous implementation of DP1 and DP3 proved difficult. Although teachers were asked to embed reading in the context of the content-area classroom (DP1), they were also asked to primarily focus their instruction on reading-related lesson goals, and not content-related goals (DP3). The effects of this complex integration were amplified by the fact that teachers themselves were unaware of this tension, and did not reflect on it until the researchers signaled the issue during the third teacher meeting. With help from the researchers, the integration of both design principles and the alignment of lesson goals and activities gradually improved, and the focus shifted from content goals to reading-related goals. However, the way in which linguistic and non-linguistic learning goals can be combined successfully is not easy to determine and also forms an issue in research on Content and Language Integrated Learning (Vasquez & Rubio, 2009). One issue that complicated the implementation of DP1 was the fact that teachers hardly found appropriate, well-structured texts in their content-area materials. This might raise questions about the ecological validity of the lesson design as a whole: if students rarely encounter well-structured texts in their school-books, why bother about teaching them about text structure? First, it is important to note that the experienced lack of suitable materials might have partially been due to teachers’ limited experience in recognizing structures themselves (see 4.2.1 and 5.2). Second, the low number of texts with a stereotypical expository text structure might also be characteristic of the limited quality of some current Dutch educational materials. For instance, Land, Sanders, and Mulder (2007) have shown that several Dutch school books suffer from a fragmented lay-out

(i.e., with every sentence on a new line), and a lack of coherence markers such as *because* and *that's why*. Perhaps educational publishers need to become aware of the need for clear text structures as well. Third, and most importantly, even if current materials display relatively few basic structures, it remains important to familiarize students with the basic structures such as compare/contrast, cause/consequence, and problem/solution. Recent research suggests that some structures are easier to learn than others, and that it is important to provide an optimal sequence that matches students' zone of proximal development (Meyer et al., 2018). This means that the basic structures are foundational for students to understand more complex and combined structures, and thereby form an important stepping stone to successful reading of authentic, less structured texts.

5.2 Support for co-designing teachers (RQ2)

It is often advocated to aim for a collaborative partnership on equal terms between teachers and researchers (e.g. Bednarz et al., 2012; Broekkamp et al., 2007), as it results in a democratic type of epistemology in which knowledge is co-constructed in a "reflexive contract." The theory-driven knowledge, views and experiences of the researcher(s) are mixed with the context-based experiences, knowledge and routines of practitioners in a continuous process of negotiation and reflection (Bednarz et al., 2012), which also leads to professionalization of teachers (Kafyulilo et al., 2014). In our study, teachers were aware of the problems in the context of reading comprehension, but due to the existing research-practice gap, their knowledge about evidence-based strategies for comprehension instruction was limited. As a result, there was some asymmetry in power between teachers and researchers in the co-design project, and extra attention was paid to promoting teacher professionalization through co-design. On the one hand, researchers took the lead by providing lots of information and a set of design principles that functioned as a stepping stone between research and practice. On the other hand, teachers had the liberty to experiment with the design principles and try-out their prototypes quite independently during the first design cycle. This collaboration between teachers and researchers was very valuable, as the process of continuous reflection and adaptation led to an interesting mix of practical and pragmatic knowledge and theoretical insights in the final prototype. Although the researchers were mainly focused on the right content of the lessons, the teachers felt the need to make sure that students would feel engaged and motivated. Therefore, they selected very challenging and interesting topics, and came up with many more engaging types of collaborative activities than the researchers could have imagined. Thanks to teachers' creativity, students were very motivated and engaged during the try-out lessons. The challenging nature of co-design at the start of a DBR project also became apparent in the amount of guidance and feedback teachers needed from the researchers; several rounds of revision were needed to successfully implement the different DPs. Teachers' lack of knowledge was most apparent in their text selection and revision; they rarely revised the texts, and if they

revised, they did not alter the structure of the text beyond the sentence level. The fact that most content-area texts were poorly structured did not help: it required teachers to become editors before they could successfully develop lessons. Teachers felt this task was too difficult, and too time consuming as well. The problem was amplified as teachers held conflicting text selection criteria, and esteemed criteria such as an engaging topic more important than a clear text structure. Another issue that was at least partially caused by teachers' lack of knowledge was a poor alignment between text, lesson goals and activities, and to only a superficial integration of the design principles in the first design. That is, teachers emphasized content-related lesson goals at the expense of (conditional) reading goals, and often did not tailor their reading strategies to the structure at hand. Also, conditional reading goals turned out to be unfamiliar for teachers; they had no idea what kind of activities could be designed in order to develop students' conditional knowledge. This issue was only resolved through intensive feedback, extra instruction with concrete examples, and discussions during teacher meetings. Asking teachers to provide well-structured texts themselves, designing lesson goals and activities while obeying various pedagogical guidelines as well, seemed too demanding for the teachers. The teachers specifically lacked pedagogical content knowledge: a specific kind of knowledge that is neither pedagogy nor content per se, but combines both in a unique way (Gudmundsdottir & Shulman, 1987). That is, the teachers in our project were able to give general instruction in reading strategies as they were used to, but when this had to be combined with specific knowledge about text structure, it soon became too challenging. This is, however, no real surprise. First, previous research has already shown that teachers' struggle with recognizing and teaching text structures (Beerwinkle et al., 2018; Reutzler et al., 2016). Second, teachers typically learn hardly anything about text structure in Dutch teacher colleges (Kooiker-den Boer, Sanders, & Evers-Vermeul, submitted). In addition, they do not usually encounter good examples in current educational materials for comprehension instruction (Bogaerds-Hazenberg et al., 2017). It is questionable whether the wide scope of knowledge and skills required for successful co-designing can actually be expected from primary school teachers. Throughout our design research, the collaborative partnership between teachers and researchers displayed characteristics of a tutor-tutee relationship. In that sense, the nature of the relationship between researchers and teachers in this relatively short DBR project was slightly different than in the original sense of co-design, not displaying all the characteristics of a reflexive contract. However, we believe that in long-term collaborations this phase of intensive support and teacher professionalization can be followed by a phase in which equal partnership develops over time. And although engaging teachers as co-designers is challenging, we also believe that it is rewarding and recommendable. With a high level of support, DBR projects can be successful. Our project illustrates how it does result in teacher professionalization. Specifically, teachers benefit from continuous feedback, discussions during teacher meetings, and

most importantly, from DPs with very concrete examples. If researchers are prepared to provide intensive support, DBR can be seen as a valuable way to simultaneously develop materials, and make insights from research accessible to teachers. Finally, for future DBR projects focused on comprehension instruction, it is recommendable to engage educational publishers, and to ask their professional editors to modify the structure of texts before teachers design lessons. This will help teachers focus on designing lesson plans alone, and might seduce educational publishers to initiate more evidence-based principles (Chambliss, & Calfee, 1998; Dewitz, & Jones, 2013). With improved texts, the content-area classroom will become a fruitful context to teach literacy.

5.3 Other factors influencing the design process

With this DBR study, we tried to contribute to bridging the research-practice gap that is very visible in the context of comprehension instruction. Due to some minor issues with the viability of the DPs and major issues that arose from teachers' lack of knowledge, the researchers had to be very actively involved in the design process by continually providing intensive support and feedback. However, only elaborating DPs and professionalizing teachers does not seem enough to actually bridge the gap. During our research it became clear that other factors were at play as well: teachers' beliefs and habits. Researchers and practitioners might hold different values and beliefs (cf., McKenney & Reeves, 2018; Voogt et al., 2011), for instance about the ideal pedagogy and curriculum content, or about their role as co-designer, which influences the final design (Cviko et al., 2014). In our project, teachers' beliefs and habits influenced both the content and the pedagogy of the designed lessons. For instance, teachers emphasized collaborative activities at the expense of individual practice, possibly because they were simply very enthusiastic about collaboration, as individual practice is very characteristic of current reading practice and collaboration might have appeared very innovative to them (Bogaerds-Hazenberg et al., 2017). Also, the teachers were reluctant to act as a coping model: instead, they always acted as mastery models as they were used to do, possibly because they were afraid to set a wrong example. Teachers' text-structure instruction was also influenced by beliefs and habits. That is, two teachers believed that challenging, authentic texts and vocabulary instruction were of utmost importance for comprehension instruction, which interfered with text-structure instruction, for which well-structured, not too complex texts were needed, so that students could solely focus on structure, without being distracted by difficult concepts. Also, all teachers were tempted to prioritize content-related lesson goals over reading goals, and actually teach geography, instead of reading comprehension. For future design studies, it is recommendable that researchers not only provide knowledge, but also be sensitive to teachers' habits and beliefs. Researchers should make an effort to discuss the value of these beliefs in relation to the design project at hand, as they might otherwise interfere with the implementation of design principles.

Our study shows that with a shared effort, DBR can generate insight into design principles, and simultaneously stimulate teacher professionalization and improvement of curricular products, thereby contributing to bridging the research-practice gap. However, it is a challenge to engage teachers as co-designers, because they are often not aware of their lack of knowledge. For a successful project, both teachers and researchers have to invest. From teachers, it requires an open mindset to learn; from researchers, it requires them to not only assume a facilitative role, but also provide adequate support and clear design principles that form a concrete stepping stone between theoretical insights and classroom practice. Co-designing might not happen in collaboration on equal terms, but with a shared effort from teachers and researchers, it can certainly contribute to teacher professionalization, and to improved curricular materials in the long run.

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