The Impact of a Digitally-Augmented Reading Instruction on Reading Motivation and Comprehension of Third Graders

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Abstract. A technical and conceptual framework is currently under development to augment the activity of reading at schools with digital media such as images, sounds and light effects. The technical framework is STREEN (Story Reading Environmental Enrichment). In this paper, we present IRIS, the pedagogical conceptual framework that describes how to employ STREEN in the classroom. We assume that STREEN/IRIS can motivate and foster reading comprehension of primary school students. We also describe an eight-weeks' study carried out with third-grade students using IRIS. This study follows a quasi-experimental pre-post design that took place at a German primary school with 56 students from three different third-grade classes to compare results between an IRIS instruction and two conventional reading instructions. The findings show that students in the experimental group improved in word and sentence comprehension and lowered their task error rate. Furthermore, their intrinsic reading motivation increased while extrinsic reading motivation decreased significantly.

Keywords: Augmented reading · Design-based research · Reader's theatre · Digital media · Children · Technology-based reading instruction

1 Introduction

1.1 Aim of the Research

Story Reading Environmental Enrichment (STREEN) is an augmented reading technical framework capable of supporting reading aloud activities at primary school by offering engaging features that promote vocabulary acquisition, reading fluency, reading comprehension and motivation. Here we present the Integrated Reading Instruction (IRIS) that uses STREEN to support students to become competent and motivated readers and teachers to use scaffolding strategies. IRIS is designed as a reader-centred instruction that attempts to meet the needs of every single student and to support students in

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achieving educational reading goals. It offers motivating tasks that promote the usage of multiple reading-related abilities. Ultimately, those tasks aim at activating the cognitive and motivational processes of reading that support students' comprehension and facing challenges to achieve competence in reading.

The investigation took place in a local primary school following a Design-Based Research approach that informed the design, implementation, and evaluation of the IRIS instruction and all the associated learning activities and technological tools.

The intervention was carried out for eight weeks, with 56 third-graders from three different classes to compare results between an IRIS instruction and two conventional reading instructions. The intervention aimed at: (i) assessing the impact of IRIS on the reading comprehension of 3rd graders, and (ii) assessing the impact of IRIS in students' reading motivation.

1.2 Background and Previous Work

In 2016 the international assessment of student's performance in reading literacy in the fourth grade [1] reported that only 43% of the students like to read. Since a positive attitude towards reading is crucial for the development of reading comprehension, it is essential to provide novel strategies to increase the effectiveness of the practices and to foster reading motivation. A reading instruction must provide explicit instruction in specific comprehension strategies and offer students a meaningful reading experience that promotes reading, interpretation and discussion of the text [2, 3]. Researchers and educational professionals are aware of the importance of digital technologies, and many would welcome new digital tools to support, complement and evolve reading instructional practices. As a response, the augmented reading technical framework STREEN (Story Reading Environmental Enrichment) is being developed to support and complement reading aloud activities at primary schools [4]. STREEN provides engaging functionalities to promote vocabulary acquisition, reading fluency and text comprehension.

The STREEN approach is related to similar attempts that use digital media to foster reading competences, including the intervention "Moved by Reading", where children read a story aloud and then move graphical elements, which correspond to the narrative [5], the project Gamelet that targets reading fluency in native and foreign languages by applying digital media-based gamification mechanisms [6], and the project LIT KIT that explores a cyber-physical system to transform read-aloud activities into a multimedia, mixed-reality experience [7]. STREEN differs from the referred approaches by stressing the story interpretation; it requires that children first collaboratively create digital media (e.g. images, sounds and light effects) that they will later employ when reading the story aloud, in front of others (see Fig. 1).

STREEN consists of a mobile application (the STREEN app) running on the student's tablet computers, a multimedia infrastructure comprising a projector, a surround sound system, smart bulbs, and a multimedia controller (the STREEN Controller) that runs on a computer server. We envision that such a media enriched environment will promote engaging and immersive reading experiences, thus increasing reading motivation and comprehension. Previous work on STREEN reported on the co-design process involving researchers, teachers, and children from a local primary school, in which the support of

Fig. 1. Primary school students interacting with STREEN in the classroom.

the acknowledged pedagogical activity Reader's Theatre with digital media was explored [4, 8].

In a preliminary study, we assessed students' acceptance of STREEN. The findings of the self-reported Unified Theory of Acceptance and Use of Technology (UTAUT) questionnaire [9] showed that most of the study participants were very interested in the technology and enjoyed reading with the STREEN app; they thought it to be helpful and showed the intention to use it in the future. The same findings were reported by the students that co-designed the STREEN prototype in participatory settings. Based on this evidence, the next step was to devise appropriate didactic methods and instructional practices to ensure sustainable motivation and reading comprehension.

2 The IRIS Instruction

IRIS stands for the Integrated Reading Instruction with STREEN and aims at fostering cognitive and motivational aspects of reading competence in upper primary school students. IRIS instruction was generated collaboratively with a third-grade teacher and researchers over six months, following design-based research methods [10]. The conceptual perspective of IRIS is that the development and growth of reading competence is a joint functioning of various cognitive, motivational, and social processes [11–13]. For an effective promotion of reading motivation and comprehension, research recommends providing multiple supportive elements [14–18]. For IRIS, we defined three supportive instructional elements: i) motivation-enhancing instructional practices, ii) motivating context, and iii) a balanced instructional structure.

2.1 Motivation-Enhancing Instructional Practices

The first element of the IRIS instruction is a set of motivation-enhancing instructional practices, designed to support students' psychological needs for relatedness, autonomy, perceived competence, curiosity and involvement in reading, as well as to help them recognise the relevance of reading and orienting them towards mastery of reading competence [14, 17, 19–24].

Accordingly, in the IRIS classroom, the teacher provides students with motivating reading materials and tasks to entice their curiosity, involving them in reading activities and tasks that allow them to experience competence and control in reading and learning. The IRIS teacher promotes students working collaboratively on achieving mastery in reading. Besides, the teacher provides opportunities for success through the transparency of goals and by helping students to evaluate their success and failures appropriately.

Providing choice, giving motivational and constructive formative feedback and assessments, offering self-reflection and -evaluation are other practices determined to support perceived competence, relatedness and autonomy, as well as mastery orientation and reading relevance. IRIS also adds the practice of scaffolding, which involves teaching and letting students apply reading strategies to influence reading self-efficacy and reading comprehension directly. Supporting students' recognition of the relevance of reading is the last practice in IRIS.

2.2 Meaningful and Authentic Context

Providing meaningful and authentic context is a commonly recommended approach to engage and motivate students in learning as well as to support their achievements [25–27]. The second element in the IRIS instruction is the motivating context, which consists of three components: 1) Reader's Theatre, 2) mini-lessons and 3) STREEN.

Reader's Theatre
Reader's Theatre is a holistic approach for reading instruction, which provides teachers with a set of effective research-based pedagogical methods and reading activities to support students in developing reading fluency, vocabulary development, interest, and confidence in reading [28–36]. Built upon positive social interactions, Reader's Theatre is a motivating and engaging activity. It provides students with a variety of authentic reading tasks, which constitute a meaningful and authentic purpose for reading and gaining comprehension. In Reader's Theatre, students read a text in the form of a script. They choose roles and practice with others that have the same script, for the final Reader's Theatre performance. Reader's Theatre motivates students to read fluently and expressively, which is achieved through repeated reading in the regular reading sessions. The students are encouraged to use their voice and read expressively to convey the content of the text (messages, characters, plots, emotions). This additionally challenges the readers' imagination and helps the audience to understand the text and the story better. For expressive reading, students have to understand the text.

Mini-lessons
In order to improve reading comprehension and performance, students need specific tools [2, 13, 37–39]. Reading strategies taught in mini-lessons is a fundamental element provided in the IRIS classroom to experience pleasure, fun and curiosity, the feeling of competence and control, and to perceive the relevance of reading. In the process of planning and practising oral reading performance, the IRIS teacher conveys reading strategies to students in small teaching units that students can directly apply [40–42]. Teacher's support reduces, and the responsibility is gradually shifted from the teacher to the students as they become more competent and can apply the strategies independently [43].

STREEN
STREEN is the third contextual component offered in the IRIS classroom. As described above, STREEN consists of a digital-media reading environment, in which students collaboratively engage in constructing a shared understanding and knowledge of the

reading materials in order to develop motivation and reading comprehension. STREEN provides a variety of technological features to support students accomplishing instructional tasks, applying strategies, reading digital texts, reflecting on reading, learning unknown vocabulary, expressing knowledge, documenting their work, and performing Reader's Theatre. It is also a tool for teachers to present instructional content, scaffold strategies, and evaluate students. In the following, we detail the main STREEN features:

Story Script: Allows the visualisation of the script and the touch-based text navigation. Additionally, in order to support children, it displays the line numbers and groups the script lines per role (see Fig. 2).

Highlight: Allows children to mark the text. The primary function of this feature is to draw attention to the lines children have to read aloud. There is a predefined highlight colour for each role. It can be alternatively used in the context of a word study strategy, such as finding unknown words (see Fig. 2).

Modelled Reading: STREEN provides a recorded modelled reading for each text. Once this functionality is activated, students can hear a human voice reading the story fluently. Children can select if they want to hear the complete story or only a part of the story. Additionally, by tapping a word, children can hear a text-to-speech generated audio and understand how the word sounds when read isolated (see Fig. 2).

Fig. 2. Story script with highlighted text (left); Story script with Modelled Reading enabled (right).

Word Cloud: Allows children to select words that will be clustered and displayed in a projection screen in the classroom. When children select a word, the word becomes surrounded by a red shape. Following the tag-cloud-like data visualisation [44], the Word Cloud provides an aggregate of word-selected statistics, displaying the word frequency information via font size (see Fig. 3).

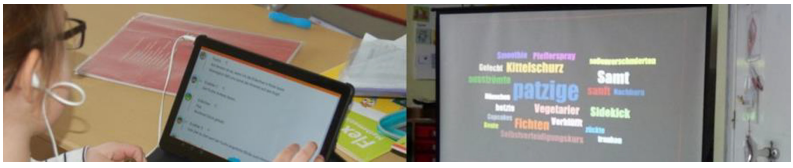

Fig. 3. A student sending unknown words to the WordCloud.

Lexicon: An integrated lexicon provides a meaning for words that are likely to be unknown by 3rd-grade children; otherwise, STREEN guides children to obtain the meaning of the word on their own, suggesting, for example, to reread the sentence.

Authoring: Allows children to associate a word of the text with a produced digital media effect. By selecting a word, children access one of the pivotal features of STREEN, which support children with drag and drop mechanisms to compose an illustration by selecting, moving, scaling, mirroring and deleting 2D graphical representations of characters and other elements of the narrative from an integrated library. Furthermore, it also offers the possibility to author the ambient light and the soundscape. This authoring process aims to stimulate children's reading comprehension [5] it requires reading carefully and working with predefined digital media elements (DME) in order to produce an illustration and other DME that match the narrative. The produced digital media effect can also be discussed in different group settings (e.g. pairs, whole-class discussion) and can also serve as an outcome that can be evaluated by the teachers. Children can at any stage of the authoring process experience their work by projecting the illustrations in the projection screen and by controlling the light and sound system installed in the room (see Fig. 4).

Triggering: After finishing the authoring process, all the augmented words (with the created digital media) appear underlined in the script view. Afterwards, children can trigger enriched words, augmenting their reading with DME. There are two interaction options to trigger the effects; children can choose between tapping the word or sliding their finger below the augmented words (see Fig. 4).

Fig. 4. STREEN app authoring environment (left); Students using the STREEN app to read and trigger digital media effects previously authored (right).

Book Cover: Uses the Triggering feature to present a digital book cover (see Fig. 5). All the STREEN texts have a predefined book cover that supports the teacher in encouraging students to predict the story, a practice that positively impacts the student's comprehension of the text [2].

Record, Listen, Reflect (RLR): Allows children to record their reading performance, listen to their records, reflect on mistakes they have done and define improvement goals (see Fig. 5). Children are guided by questions, which allow them to assess their performance, (e.g. Did I pronounce every word correctly? Have I paid attention to punctuation and its meaning? Have I read at a reasonable pace?).

Fig. 5. Students make predictions of the story (left); a student using the functionality "Record, listen, reflect" to improve his reading fluency (right).

For the integration of STREEN into the reading instruction, we determined principles based on the current research [45–50]. Each student had a tablet set up with the STREEN app that allowed her/him to read digital Reader's Theatre scripts, study unknown words, practice reading fluency, collaborate with peers, create and trigger digital media effects, and discuss and present their performance and outcomes. The IRIS teacher scaffolds the use of the STREEN features one at a time according to students' needs and gradually hands over the responsibility to the students as they become acquainted with a particular feature. In practice, the teacher first explains and presents to students how to operate the tablet and certain STREEN features, and after that, the students receive tablets and try out the application. To avoid distractions and to enable a smooth use of STREEN and the creation of digital media effects, teachers and students set rules and regulations for how to behave, work, and communicate with each other when using STREEN. The students are allocated sufficient time to practice and use the STREEN app.

2.3 Balanced Instructional Structure

The third and last condition of the IRIS framework is the balanced instructional structure [26, 51, 52]. Following the baseline offered by the classical Reader's Theatre [35, 36], this framework provides a contextual structure that helps in the design of a weekly reading instruction, ideally divided through five days, with an hour per day. During the week, students get familiar with the theatre script, plan the performance, rehearse, and execute the final performance in front of an audience. At the day-level, the targeted instruction is divided into three phases: 1) getting started, 2) elaboration, and 3) fading out [52]. Each phase is subdivided into sequences (see Fig. 6). This granular way of structuring the day provides a guideline for the teacher to plan the IRIS instruction and easily integrate the multiple supports that IRIS proposes for fostering reading motivation and comprehension.

The Getting Started Phase

The IRIS instruction begins with catching students' attention by activating their prior knowledge and experience; asking for anticipation and predictions to trigger their curiosity, involvement, and to support perceived competence and collaboration. Afterwards, in order to support the value of reading and emphasise mastery goals, the teacher clearly communicates to the students the learning goals and their inherent challenges. In that way, the students learn what goals need to be achieved in order to become competent readers and which tasks they have to perform to achieve personal mastery goals.

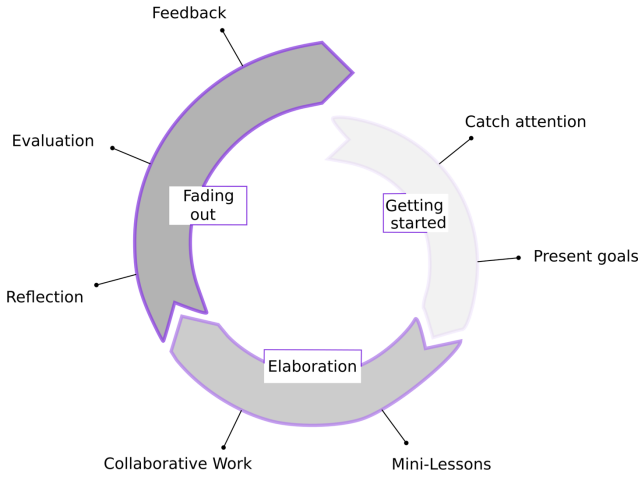

Fig. 6. The three phases of the instruction and the inherent activities.

With this knowledge, the students are prepared and can participate actively and without distractions towards achieving reading competence [53, 54].

The Elaboration Phase
The elaboration phase is sequenced in scaffolding strategies and offering collaborative work. Both sequences are part of the mini-lessons, in which the IRIS teacher conveys reading strategies and offers opportunities to apply them with STREEN and with other motivating teaching materials during the preparation for the Reader's Theatre performance.

The Fading Out Phase
The IRIS instruction ends with students reflecting on their learning process, progress and outcomes for an accurate self-evaluation. Feedback from the teacher, the peers and the teacher's assessment complete the final instructional phase. Ultimately, the teacher encourages students to participate in a voluntary homework assignment that consists of a small reading task related to the current instruction, which the students can accomplish for preparation for the next instruction and for maximising learning effects in strategy use and reading competence development. Over time, students internalise the instructional structure and can focus more on the content and participation rather than dealing with the question about what comes next, whether they will receive feedback or have time for reflection [52, 55, 56].

3 Implementation of IRIS at Primary School

As a first step for the integration of the IRIS framework, we established a partnership with a local primary school. Afterwards, a team composed of two researchers and one third grade teacher used the IRIS framework and worked for four months in the design of an eight-weeks IRIS instruction.

As a starting point, we identified and integrated cognitive components related to the reading competence, such as word recognition, reading fluency, and reading comprehension in the instructional framework elements. This identification and integration process was grounded in principles aimed at promoting reading comprehension and constrained by the specific requirements of each stage of Reader's Theatre. The following subsections present a model of a week instruction.

3.1 Monday

On the first day of the week, a new story is introduced. Research has shown that encouraging students to use their prior knowledge and to predict the content of a text can positively impact their comprehension of the text [2]. For that reason, on Mondays, the catch attention activity starts by activating relevant background knowledge about the story's topic, followed by an activity lead by the teacher, in which students are asked to anticipate and predict the plot of the narrative based on the analysis of the book cover that is displayed on the STREEN system (see Fig. 5). When a new text genre is introduced, e.g., fairy tales or fables, the teacher informs students about the essential characteristics of the text genre. After that, the teacher presents students the weekly schedule in which the week and daily goals are presented and facilitates a discussion aiming at the common understanding of the goals. In the elaboration phase, the teacher models reading aloud, and the students listen attentively. That can be done by having the teacher reading the script directly with the STREEN app or by allowing the students to hear a modeled reading through the STREEN app. Since it is crucial that students have the possibility to clarify unknown words at an early stage, STREEN provides a functionality, named WordCloud, that allows students to mark unknown words in the text and send them to a projection screen (see Fig. 3). The Word Cloud aims at supporting teachers and students in the activity of identifying, grouping and visualising unknown words, as well as to support the learning and application of strategies to discover the meaning of the words such as using an incorporated lexicon or context analysis. In the fading out phase, the students reflect on their reading process and progress and receive feedback from their peers and the teacher. At the end, students are encouraged to read the full script at home in order to achieve a deeper understanding of the narrative and to be better prepared to choose a role in the following day.

3.2 Tuesday

On Tuesday, the students choose their role and work on the common understanding of the text. The instruction starts by activating prior knowledge about the characters which are displayed on the projection screen and communicating the goals and challenges of the day. In the mini-lesson, the teacher forms small groups in which the students then choose and highlight their roles using the STREEN app (see Fig. 7). Following this, the students use the STREEN app to create a limited amount of digital media effects for their lines (see Fig. 7). This authoring process is targeted to support the learning and application of comprehension strategies such as Visualization, Questioning and Think-aloud [2]. While authoring, children have to use their imagination and develop their capacity for generating questions, which help them to understand the text they have to

"illustrate" and complement with digital media effects (e.g. images, sounds and light effects). Additionally, children have to discuss and collaborate in order to guarantee the coherence among the different digital media effects created by the different students (see Fig. 7). This cooperative activity requires children to learn and use the think-aloud strategy. The unit ends with the reflection and evaluation phase. To practice fluency, the students are asked to read their role at home.

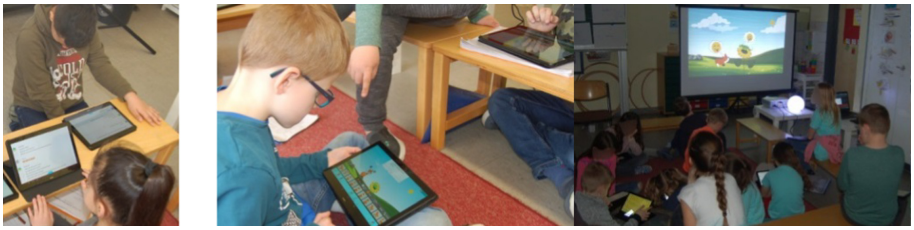

Fig. 7. Students marking their roles (left); students creating and discussing the DME (right).

3.3 Wednesday

The third day of the week is dedicated to finalising the authoring process. In the catch attention phase, the teacher uses the STREEN app to read and trigger digital media effects, which purposefully present errors and incoherencies. For instance, the teacher uses illustrations that do not match the text. This way, the teacher aims to stimulate children's awareness of digital media effects problems and to foster their capacities to analyse and constructively criticise digital media effects created by the other students. It also shows the teacher how well the students have understood the text, e.g. when they identify the mismatch between text and pictures. It follows the communication of the daily goals, which is deepening the text comprehension through the authoring process. In the elaboration phase children refine and finish the digital media effects. Before the reflection and feedback routine, the students use the STREEN app to read and to trigger digital media effects. By doing so, students practice reading in a group, the reading fluency and automaticity of triggering the effects in the right moment. In the last point of the fading out phase, the students are asked to read their role at home in order to improve their reading fluency and to increase their confidence.

3.4 Thursday

This is the penultimate day, the rehearsal day that precedes the final performance. Since the catch attention phase relates to the daily goals, the teacher reads a part of the script with a poor reading fluency performance and encourages their students to identify the problems, e.g., wrong prosody or tempo. Afterwards, the teacher communicates the goals and challenges of the day. In the elaboration phase, students are invited to use the STREEN app functionality "Record, listen, reflect." With this functionality, the students can listen to the pre-recorded reading aloud of the text either wholly or line by line.

Additionally, the "Record, listen, reflect" functionality allows them to record reading, listen to their records, identify/reflect on mistakes and define goals for improvement (see Fig. 5). With this approach, students are encouraged to engage in an improvement cycle targeted towards the mastery of oral reading fluency. The last action in the elaboration phase is the final rehearsal where students read their parts while triggering the digital media effects. The teacher can interrupt the performance to provide direct feedback and instructions. The unit finishes with reflection and feedback routine. This routine is used to give and receive feedback from the peers and the teacher. Once again, the students are invited to rehearse reading their role lines at home.

3.5 Friday

On Friday, the reading instruction is dedicated to the final performance in front of an audience previously selected by the students (see Fig. 4). In the catch attention phase, the teacher does warm-up exercises with the students to prepare them for reading aloud, to ease arousal and increase concentration. After the day's goal is presented, it is the students turn to perform their reading aloud, which they start after the technical check of the STREEN system. Once the students have performed the Reader's Theatre, they receive direct feedback from the audience and the teacher. The audiovisual recording of the final performance can be used to support reflection and feedback. The instruction ends with students' reflection and evaluation of the week.

4 Research Questions

This investigation aimed at answering the following research questions:

1. What is the impact of the use of IRIS on the reading motivation of 3rd graders?
    a. What is the impact of the use of IRIS on the intrinsic reading motivation of 3rd graders?
    b. What is the impact of the use of IRIS on the extrinsic reading motivation of 3rd graders?
    c. How did the levels of reading motivation of IRIS' students evolve when compared to the conventional reading instructions students?

2. What is the impact of the use of IRIS in student's reading comprehension?
    a. What is the impact of the use of IRIS in student's reading comprehension at the word level?
    b. What is the impact of the use of IRIS in student's reading comprehension at the sentence level?
    c. What is the impact of the use of IRIS in students' overall reading comprehension (word and sentence level)?
    d. Does the prior tablet experience affect the impact of IRIS on reading comprehension?

e. How did the levels of reading comprehension of IRIS' students evolve when compared to the conventional reading instructions students?
f. How did the levels of reading comprehension of IRIS' students evolve when compared to the national baseline?
g. How did the error rates levels of IRIS' students evolve when compared to the reading instructions students?

5 Research Study

To answer these research questions, we carried out an eight-weeks comparative study. We focused on third-grade students because it is crucial to start early to counteract reading comprehension and motivation problems, which increase in particular from the upper primary school grades [12, 57, 58]. At this stage, students are supposed to have acquired the fundamental reading skill of fluently decoding the text that makes them capable of evolving their reading comprehension and starting applying reading strategies. Teaching students reading comprehension is an important goal in upper primary school grades. The German curriculum foresees that students have acquired the basic reading skills by the beginning of the third year of school and can then focus on advanced skills (reading competence).

5.1 Participants

The study was carried out with 56 students from three third-grade classes from a primary school in Germany. The children were aged between 8 and 9 years old ($M = 8.32$, $SD = 0.47$); 49% were female. One class (20 children) was assigned to the experimental group using the IRIS instruction, another class (16 children) was assigned to the control group using the Reader's Theatre instruction (RTI), the third class (20 children) was assigned to the control group using a conventional reading instruction (CRI). Two children in the IRIS group and one child in the RTI group could not complete the demographics questionnaire, leaving 18 children in the IRIS group, 15 children in the RTI group and 20 in the CRI group. Details of demographics and tablet use information of the study participants are presented in Table 1.

5.2 Design

The study used a quasi-experimental design that included one experimental group (IRIS integrated reading instruction with STREEN) and two comparison groups (traditional Reader's Theatre instruction and conventional reading instruction).

5.3 Assessment Materials

Reading Comprehension
Reading comprehension was assessed in a pre and post-test with a paper-pencil normalised ELFE II test [59]. This test is divided into three subtests, word comprehension,

Table 1. Participant's demographics and computer literacy.

	Full sample	IRIS	RTI	CRI
Female	49.1%	50.0%	53.3%	55.0%
Age	8.32	8.44	8.20	8.30
Birthplace				
Germany	86.8%	94.4%	73.3%	90.0%
Other	13.2%	5.6%	26.7%	10.0%
Parents' birthplace				
Germany	46.2%	38.9%	33.3%	63.2%
Mixed	21.2%	16.7%	33.3%	15.8%
Other	32.7%	44.4%	33.3%	21.1%
Language at home				
German	49.1%	50.0%	26.7%	65.0%
Mixed	41.5%	38.9%	60.0%	30.0%
Other	9.4%	11.1%	13.3%	5.0%
Daily tablet use				
Never	34.6%	33.3%	53.3%	21.1%
Less than 30 min	26.9%	27.8%	13.3%	36.8%
30 to 60 min	9.6%	16.7%	0.0%	10.5%
1 to 2 h	17.3%	11.1%	20.0%	21.1%
More than 2 h	11.5%	11.1%	13.3%	10.5%

sentence comprehension and text comprehension. The word comprehension subtest comprises 75 items. In this subtest, each item presents one picture, and four words and students are required to mark the word that matches the picture. The sentence comprehension subtest consists of 36 items. The items present sentences in which a suitable word is missing and has to be selected and inserted from five alternatives offered. The text comprehension subtest includes 26 short text passages with associated multiple-choice questions. The task is to answer the question by selecting the appropriate one from the four answer alternatives offered. Students from the three study groups were given all three subtests. For the analysis, the text comprehension subtest was removed on account of its invalidity (ELFE II Manual). The data collected indicated that the processing of the subtest was invalid. The students of the experimental group were impeded completing the test by several internal circumstances.

Reading Motivation

Reading motivation was assessed through a survey designed to assess (i) intrinsic and extrinsic reading motivation (incentives within the reading process), (ii) reading self-efficacy (ability to perform reading well), and (iii) the importance of reading (perceived

significance and utility of reading). As theorised by Schiefele, the last two are the antecedents of reading motivation [60]. Intrinsic reading motivation refers to curiosity (interest related to the reading of particular text genre and topic) and involvement (experiences of enjoyment, deep absorption, and imagination, for example, getting involved with the characters in the story). The extrinsic reading motivation encompasses two dimensions: competition (outperform other students in reading) and recognition (get praise for good reading). Due to the lack of a uniform operationalisation of reading motivation and the inexistence of a standardised reading motivation questionnaire that covers all components of reading motivation, we combined the items from different standardised reading motivation questionnaires. Intrinsic and extrinsic reading motivation, as well as reading importance, were measured through the Reading Motivation Questionnaire for Elementary Students (RMQ-E) [61] and the Reading Motivation Questionnaire (RMQ) [62]. The Scale for Self-Concept in Reading [63] served to assess students' perception of reading self-efficacy. Our questionnaire initially contained 33 items and was applied in a pre-pre test to 16 students from another third-grade class of the same school who did not participate in the study to measure the questionnaire's reliability. The factor-analytical evaluation of the data showed that the questionnaire had a high reliability of cronbach's alpha .815 to measure the composition of reading motivation. A look at individual items showed that this could be increased to .839 by excluding some items. Since we also aim to measure the influence of IRIS on individual components of reading motivation, we have also performed the factor analysis for the respective reading motivation components. This has also given us a deeper insight into which items should be removed. The survey consisting of 29 items was conducted with the paper-pencil method. All items were worded in the standard statement format (e.g. "I read because reading is fun") requiring the participants to indicate how these statements applied to them on a four-point rating scale (1 = no, 2 = rather no than yes, 3 = rather yes than no, 4 = yes).

5.4 Procedure

From the beginning of the school year 2018/19 until mid-December 2018, we had several organisational meetings with the school director and the three teachers responsible for the experimental and the control groups to explain our research and to plan the study. Before Christmas holiday 2018, we distributed the informed consents describing the research procedures and data acquisition to parents. Parents and children were clearly informed (and agreed to) that the researchers might use and share data, including video, images, in publications or presentations for academic purposes. After parents signed and returned the consent forms and all children assented to participate in the study, we briefed the three teachers responsible for the experimental and the control groups about how to administer the data collection. Prior to the beginning of the intervention, the collection of the pre-test data was carried out within one week for the three groups, in three consecutive days, with the first-day directed for reading motivation, the second day for demographics and computer literacy and the third day for reading comprehension. In order to ensure anonymisation, all the questionnaires were coded by the teachers.

Following the pre-test week, the three groups engaged in a period of eight weeks of classroom instruction, in a total of 40 daily sessions, each with the duration of 60 min, carried out between 10:00 AM and 11:00 AM.

The teacher of the students in the experimental group was trained in IRIS instruction and assisted by one of the researchers responsible for providing support in setting up the STREEN infrastructure. Since the IRIS instruction follows a weekly cycle, a week in advance, the teacher received all the necessary materials to conduct the upcoming week of instruction. These materials always included a printed version of the goals for the week (see Fig. 6), to be posted in the classroom, the reading fluency checklist to support the Record, Listen, Reflect functionality, and for each student and teacher, a printed copy of the week plan and an updated version of the STREEN application comprising the story with related digital media running on a 10.1-in. tablet computer. Every week, reading strategies were gradually introduced to the students and applied throughout the week as tools for developing reading fluency and reading comprehension. The teacher was additionally provided with a printed procedural instruction, which included teachers and students actions, tasks for the students, and explanations on how to use specific features of STREEN. Finally, in the first week, we also provided a list of rules on how to use STREEN in A1 size format to be posted in the classroom.

For each of the eight-weeks, we selected one story, in the first four weeks, we used fairy tales, and in the following weeks fables. In order to address the gradual release principle, the STREEN features were introduced during the first four weeks. In the first week, we also had to introduce children to the procedure inherent to readers' theatre.

The instructions in the two control groups were conducted in parallel in two other classes of the same primary school. The first control group used traditional Reader's Theatre instruction and the second class used conventional instruction for reading competence promotion. All groups read the same story in the same week. A printed copy of the eight-story scripts given to each student and teacher from the experimental group was provided to the two control group teachers in the pre-test week. The script text of these printed versions was formatted according to the digital script used by the experimental group, e.g. font type/size and line spacing.

Directly after the last week of instruction, the collection of post-test data was carried out within one week in four consecutive days, with the first day dedicated to reading motivation, the second day for demographics and computer literacy, the third day for reading comprehension and the fourth day for instruction feedback (only administered to the experimental group).

6 Results

Before the intervention, the teachers conducted pre-tests assessing students' reading comprehension and motivation. The post-tests were carried out the week following the last instruction. Two children in the IRIS group and three children in the CRI group could not complete the reading comprehension questionnaire, remaining a total of 18 participant children in the IRIS group, 16 in the RTI group and 17 in the CRI group. A similar situation happened with the reading motivation questionnaire, leaving 18 children in the IRIS group, 13 in the RTI group and 19 in the CRI group.

6.1 The Impact of IRIS on Reading Comprehension

To investigate the impact of IRIS on the reading comprehension, we first run tests to analyse the data collected from the ELFE II subtests indicated by the number of correct answers. For measuring the impact of IRIS on word comprehension, we ran a t-test with results showing that the word comprehension ($M = 46.89$, $SD = 2.09$) increased significantly after the eight-weeks IRIS instruction ($M = 54.00$, $SD = 1.58$, $t(17) = -6.65$, $p^{**} < .01$). In the same way, students' sentence comprehension ($M = 45.61$, $SD = 9.79$) increased significantly after the intervention ($M = 50.67$, $SD = 2.18$, $t(17) = -6.89$, $p^{**} < .01$). Regarding the overall performance in reading comprehension (word and sentence comprehension), the IRIS class also showed significant improvement from the pre-test ($M = 46.00$, $SD = 2.20$) to the post-test ($M = 52.50$, $SD = 1.89$, $t(17) = -7.87$, $p^{**} < .01$). In terms of the impact of prior tablet experience on the overall performance in reading comprehension, the results indicate that the children with less table experience (less than 30 min per day) present a lower improvement ($n = 11$, $M = 48.00$, $M = 53.27$) when compared with children with more experience ($n = 7$, $M = 42.86$, $M = 51.29$); however, a two-way ANOVA with repeated measures indicated that this between-group difference was not statistically significant ($F(2) = 4.109$, $p = .06$).

6.2 The Impact of IRIS on Reading Comprehension in Comparison with Two Control Groups

As a starting point, we compare the competence of the three different classes before the treatment. The analyses of variance yielded no significant difference between the classes ($F(2) = 1.779$, $p^{*} > .05$). With regard to the overall reading comprehension, the classes improved during the intervention significantly ($F(2) = 287.505$, $p^{**} < .01$) and they differed significantly between each other ($F(2) = 6.337$, $p^{**} < .01$). The pairwise comparison reveals that the CRI ($M = 49.71$, $M = 60.53$) and RTI classes ($M = 43.19$, $M = 53.25$) differ significantly ($M = -6.899$, $p^{*} < .05$). Regarding the word comprehension, all groups scored significantly higher ($F(2) = 144.068$, $p^{**} < .01$). However, the differences between the groups were not significant ($F(2) = 2.861$, $p^{*} > .05$). For assessing the differences between the groups on the sentence comprehension, we ran the Kruskal-Wallis test because of the significance in the Levene's test. The three classes improved their levels of sentence comprehension after the intervention and the difference was significant between the groups ($H(2) = 8.453$, $p^{*} < .05$). The improvement of IRIS group was the lowest and differed significantly compared with CRI ($H(2) = 6.868$, $p^{**} < .01$) and RTI ($H(2) = 5.474$, $p^{*} < .05$).

In terms of the amount of items answered, the results revealed that the IRIS class ($M = 65.11$, $M = 75.28$) scored higher after the intervention. However, there was an even stronger increase in the CRI ($M = 72.12$, $M = 98.47$) and RTI classes ($M = 58.56$, $M = 85.00$). A two-way ANOVA with repeated measures indicated that the three groups scored significantly higher after the intervention ($F(2) = 294.178$, $p^{**} < .01$) and that groups differed significantly from one another ($F(2) = 20.132$, $p^{**} < .01$). The pairwise comparison shows that the CRI class significantly differs with RTI ($M = 13.513$, $p^{**} < .05$) and IRIS ($M = 15.100$, $p^{**} < .05$). Regarding the amount of errors, the results show that the IRIS class reduced the average amount of errors ($M = 2.78$,

$M = 1.44$), whereas the CRI class ($M = 2.29$, $M = 3.59$) and the RTI class ($M = 1.88$, $M = 2.06$) increased the average amount of errors. In the last step of the analysis, we assessed the error rate that is calculated by dividing the number of error occurrences by the total number of items answered. The results revealed that the IRIS was the class that registered the strongest decrease in the error rate ($M = 0.051$, $M = 0.022$), followed by the RTI class ($M = 0.033$, $M = 0.026$). Contrary to the two previous groups, the CRI class slightly increased the error rate ($M = 0.033$, $M = 0.039$). The distribution of the difference between post error rate and pre error rate between the groups was significant ($H(2) = 7.248$, $p^* < .05$). The post-hoc tests reveal that the error rate difference in the IRIS class ($M = -.0288$) significantly differed from the CRI class ($M = .0056$, $H(2) = 2.681$, $p^* < .05$).

Finally, the normed data for the reading comprehension test shows that although the improvement of the IRIS class was the lowest, the students improved compared to the official reading comprehension baseline in Germany which is provided by a t-test ($t(17) = -2.78$, $p = .013$). In the pre-test, the experimental group scored 46% higher than the sample used to create the official baseline. In the post-test, the results from the experimental group were 52% higher than the normed sample.

6.3 The Impact of IRIS on Reading Motivation

To assess the impact of IRIS on reading motivation, we applied the non-parametric Wilcoxon test for dependent samples due to the lack of normal distribution of the data. For the composite reading motivation, the test reveals that reading motivation in IRIS students ($n = 18$) differ significantly after participating in the IRIS instruction ($M = 3.03, M = 3.15$), $z = -2.526$, $p^* < .05$. The intrinsic reading motivation did not improve significantly ($M = 3.53$; $M = 3.38$), $z = -1.438$, $p^* > .05$. On the dimension curiosity, students in the IRIS class scored lower after the intervention ($M = 3.47$; $M = 3.30$), $z = -1.658$, $p^* > .05$, so also was the impact on the dimension involvement ($M = 3.59$; $M = 3.49$), $z = -1.089$, $p^* > 05$. In contrast, extrinsic motivation decreased significantly ($M = 3.18$, $M = 2.28$), $z = -3.668$, $p^{**} < .01$. On the dimension competition ($M = 3.21$; $M = 2.26$), $z = -3.632$, $p^{**} < .01$ and recognition ($M = 3.06$, $M = 2.33$), $z = -2.289$, $p^* < .05$ students scored significantly lower after the intervention. Regarding reading self-efficacy, after the intervention there was a non-significant increase ($M = 2.89, M = 2.94$), $z = -.701$, $p^* > .05$ in students' perception of being able to read well. Students perceived the importance of reading slightly lower after the intervention, but not significantly ($M = 3.68$, $M = 3.57$), $z = -1.897$, $p^* < .05$.

6.4 The Impact of IRIS on Reading Motivation in Comparison with Two Control Groups

For comparing the changes in reading motivation between the classes, we ran the Kruskal-Wallis test for independent samples due to the lack of normal distribution in most of the values. For the composite reading motivation, we reverse coded the items competition and recognition. The Kruskal-Wallis test revealed that the changes between the groups differ significantly ($H(2) = 10.828$, $p^{**} < .01$). The composite reading motivation increased in IRIS ($M = 3.03$, $M = 3.15$) and RTI class ($M = 2.90$, $M = 2.95$); in

contrast, decreased in CRI class ($M = 3.32$, $M = 3.19$). The post-hoc tests reveal that the difference is significant between CRI and IRIS ($H(2) = -3.181$, $p^{**} < .01$).

The intrinsic reading motivation, composed of dimensions curiosity and involvement changed after the intervention in all classes significantly ($H(2) = 6.328$, $p^{*} < .05$). Only the students from the RTI class improved slightly ($M = 3.10$, $M = 3.12$). The CRI class ($M = 3.64$, $M = 3.34$) differed significantly from the RTI class ($H(2) = -2.416$, $p^{*} < .05$). Looking at the individual dimensions, with regard to curiosity, it diminished in the students of all three classes and the changes did not differ significantly between the classes ($H(2) = 1.625$, $p^{*} > .05$). For involvement, the difference between the classes was significant ($H(2) = 11.841$, $p^{**} < .05$). Involvement in students from RTI class increased ($M = 3.05$, $M = 3.15$). In the other two classes this dimension diminished, particularly in the CRI class ($M = 3.70$, $M = 3.20$). The pairwise comparison shows that the changes in the CRI class significantly differ from the IRIS class ($H(2) = -2.750$, $p^{*} < .05$) and RTI ($H(2) = -3.076$, $p^{**} < .01$).

The extrinsic reading motivation, composed of the dimensions competition and recognition decreased in all classes significantly ($H(2) = 7.749$, $p^{*} < .05$). The post-hoc tests show that the IRIS class ($M = 3.18$, $M = 2.28$) significantly differ from the RTI class ($M = 2.69$, $M = 2.48$), $H(2) = 2.554$, $p^{*} < .05$. Regarding competition, all classes decreased and the changes between the classes were significant ($H(2) = 12.620$, $p^{*} < .05$). The difference between the IRIS ($M = 3.21$, $M = 2.26$) and the CRI class ($M = 1.36$, $M = 1.16$) was significant ($H\ (2) = 3.501$, $p^{**} < .01$); whereas not between the IRIS and the RTI class ($M = 2.71$, $M = 2.35$, $H(2) = 2.158$, $p^{*} > .05$) and between RTI and CRI ($H(2) = 1.017$, $p^{*} > .05$). On the recognition dimension, the changes between the classes differ significantly ($H(2) = 10.024$, $p^{*} < .05$). The CRI class decreased ($M = 2.41$, $M = 1.12$) and differs significantly ($H(2) = -3.120$, $p^{**} < .01$) from the RTI class that increased on this dimension ($M = 2.62$, $M = 3.00$). There was no difference between CRI and IRIS ($M = 3.06$, $M = 2.33$), $H(2) = -.996$, $p^{*} > .05$). The difference between IRIS and RTI was not significant ($H(2) = 2.232$, $p^{*} > .05$).

For reading self-efficacy, the classes did not differ significantly ($H(2) = 1.000$, $p^{*} > .05$). Looking at the means reveals that there is a drop in reading self-efficacy in the CRI group ($M = 2.81$, $M = 2.79$). IRIS ($M = 2.89$, $M = 2.94$) and RTI ($M = 2.91$, $M = 2.93$) increased slightly. Reading importance in IRIS students ($M = 3.69$, $M = 3.57$) and CRI students ($M = 3.61$, $M = 3.04$) decreased. Only the students in the RTI class improved on this reading motivation component ($M = 3.10$, $M = 3.18$). A Kruskal-Wallis test revealed that the changes between the classes are significant ($H(2) = 6.618$, $p^{*} < .05$). The CRI class differed significantly from the IRIS ($H(2) = -2.215$, $p^{*} < .05$) and the RTI ($H(2) = -2.157$, $p^{*} < .05$). No significant difference was found between IRIS and RTI ($H(2) = .131$, $p^{*} > 0.05$).

7 Discussion

The results presented above reveal that the students that experienced the eight- weeks IRIS instruction showed gains in reading motivation and comprehension. Although the IRIS group was only able to outrange the control groups in some of the components (e.g. reading comprehension error rate, extrinsic reading motivation), the results are

promising. The results indicate that advancing the reading instruction with the STREEN digital-media technology, integrating sound practices for promoting motivation and text comprehension, can support the development of reading comprehension and motivation in third-grade students.

An important aspect is that it requires time to learn how to use the technology properly in an educational context [23, 48]. In fact, in this study, we observed that IRIS students less experienced with tablet devices improved poorly in reading comprehension when compared with more experienced children. This does not forcefully mean that we need an explicit training period before starting the instruction, but certainly implies changes in the planning of the gradual release model. It will also imply that future studies integrate an additional measurement point in time directly after the familiarisation period in which teachers and students get used to STREEN. Additionally, even though we acknowledge the potential of the technology to create rich environments that can motivate students and enhance learning, we are also aware of its harmful potential to distract students and negatively influence learning [23, 45]. Furthermore, very often, the gains in motivation are due to the novelty of the technological tools, and there is a tendency of decrease in motivation with time [23, 45, 50]. Our investigation aims at better understanding the influence of time on motivation. It may also be that the high motivation to use the technology, in the beginning, has slowed down the development of reading comprehension. Accordingly, future study designs need to consider the integration of more than two measurement points.

It is also valid to say that time is needed to get familiarised with all the novelties offered by the IRIS concept. The students had to adapt to the new routine, and so did the teacher. For instance, the implementation of Reader's Theatre was certainly an additional challenge at the beginning of the eight-weeks instruction. Over time, the students became much more confident in using the technology and in mastering different aspects of the IRIS instruction.

Finally, the teachers' influence may have created a bias. The influence of teachers on students has been known for a long time. First, teachers carried out the tests, and this might have affected the results. For example, it was surprising that the IRIS class scored worse in the text reading comprehension post-test than in the pre-test. A noticeable number of students had not got very far in the test, which suggests that something had happened in the last subtest of reading comprehension. Second, the students and the teacher might as well felt too much pressure to show good results, negatively impacting the test results. Finally, we need to consider the influence of teachers on students' learning and gaining competencies, motivation, emotions. For that, we will need to evaluate IRIS with different teachers and collect data from students about their attitude towards their teachers and consider it in the analyses. The results from the comparison of the IRIS class with the normed data from the ELFE-test strengthen this assumption.

8 Conclusion

In this paper we have presented the instructional framework IRIS, a framework that was created based on the existing research literature and that was developed through a close cooperation between researchers and a third-grade teacher from a German primary

school. IRIS provides a holistic approach for fostering the reading competence of upper primary school students. This approach allows children to become competent and motivated readers. IRIS uses the potential of digital media to promote reading motivation and comprehension through the systematic integration of STREEN into instructional practices providing a pedagogical-media concept for digital media-based teaching and development of reading competence. Additionally, we have presented an exemplary IRIS instruction that was created for third-grade students. We have also described an eight-weeks comparative study aimed at understanding the impact and quality of the IRIS instruction framework and reported results, which indicate positive effects on students' reading comprehension and motivation. These results show some possible influences on the instruction and require further investigations. In future work, we plan to deepen the data analysis regarding the students and teachers' feedback and to use the insights from this study to redesign and enhance the IRIS framework and the STREEN technology.

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