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Gender gap in reading digitally? Examining the role of motivation and self-concept

Abstract

Reading is a core prerequisite for educational success and participation in society. However, comprehensive empirical research is needed to understand how reading may differ in a digitalized world. The current study addressed the gender gap in reading digitally. It investigated competence scores along with information on (a) reading and (b) digital motivation and self-concept in 588 elementary school students. Results revealed a gender gap in reading digitally, in reading motivation and self-concept, and in motivation and self-concept in respect to working on digital devices. Only reading motivation variables predicted reading digitally, thereby providing important information on the validity of digitally based reading tests. Reading motivation was found to fully mediate the gender effect on reading digitally. Results have important implications for research and practice.

Keywords

Reading; Motivation; Digitalization; Elementary school

Geschlechtsunterschiede im Lesen an digitalen Geräten? Analysen zur Rolle von Motivation und Selbstkonzept

Zusammenfassung

Lesen ist eine zentrale Voraussetzung für Bildungserfolg und gesellschaftliche Teilhabe. Wegen der fundamentalen Bedeutung des Lesens sind umfassende empirische Erkenntnisse zu der Frage, wie sich das Lesekonstrukt im Zuge der Digitalisierung verändert, notwendig. Vor diesem Hintergrund analysierte die vorliegende Studie Geschlechtsunterschiede im Lesen an digitalen Geräten. Neben

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Lesekompetenzen an digitalen Geräten wurden intrinsische Motivation und Selbstkonzepte in den Bereichen (a) Lesen und (b) Arbeit an digitalen Geräten von 588 Grundschulkindern betrachtet. Mädchen und Jungen unterschieden sich in der Lesekompetenz, in lesebezogener Motivation und Selbstkonzept sowie in Motivation und Selbstkonzept zur Arbeit an digitalen Geräten. Ausschließlich lesebezogene motivationale Merkmale sagten die Lesekompetenz vorher, was auf die Validität des Lesetests hinwies. Außerdem mediierte die intrinsische Lesemotivation die Geschlechtsunterschiede in der Lesekompetenz vollständig. Die Ergebnisse haben wichtige Implikationen für Bildungsforschung und -praxis.

Schlagworte

Lesekompetenz; Motivation; Digitalisierung; Grundschule

1. Introduction

One core development and challenge of our modern times is the digitalization of many parts of society. This also includes education in which acquiring information by reading digitally has become a frequent activity within both school instruction and out-of-school learning (Mangen & van der Weel, 2016). However, it is not yet clear what implications digitalization is having – not only for the construct of reading literacy itself but also for the research findings on reading gathered in past decades using paper-based assessment. One core finding on reading is the school age gender gap.

Gender is a core aspect of being human; and substantial research and educational measures have focused on gender differences in reading (McGeown, Goodwin, Henderson, & Wright, 2012). Results on competence have been heterogeneous, with evidence indicating not only better performance in school-age females (Mullis, Martin, Foy, & Hooper, 2017; but see also Hyde & Linn, 1988) but also slightly better performance in adult males (Organisation for Economic Cooperation and Development [OECD], 2013). A clear pattern has emerged indicating that girls are, on average, more highly motivated to read and also read more in their free time (McElvany, Kessels, Schwabe, & Kasper, 2017; McKenna, Conradi, Lawrence, Jang, & Meyer, 2012).

However, it is necessary to verify whether these results generalize to reading digitally and digital reading. Recent research has pointed out that gender differences in digital reading still exist, but that they might be smaller than in paper-based assessments (Mullis et al., 2017). One possible explanation for this emerging pattern might be found in motivational variables (e.g., Becker, McElvany, & Kortenbruck, 2010). Some evidence has suggested that motivational constructs with regard to digital devices and their usage show either no or, at times, different gender differences compared to reading motivation and behavior when reading paper-based materials (Lorenz, Gerick, Schulz-Zander, & Eickelmann, 2014).

Against this background, the current study aimed to investigate a potential gender gap in reading digitally, the predictive value of motivational variables for working with digital devices, and the predictive value of traditional motivational variables for reading in general. It also examined the potentially mediating role of these motivational variables for gender differences in the proficiency of reading digitally.

2. Theoretical background

2.1 Reading literacy: Definition, development in elementary school age, and international assessments

Reading literacy includes the ability to extract relevant information from, understand, use, and reflect on written texts. According to Kintsch (1988), a text can be represented on three different levels: (a) the surface level representing the verbatim text structure, (b) the text level including the text basis and its elaborations representing text propositions (semantics), and (c) the situational model level integrating the text content with the readers' knowledge. Following Kintsch's (1988) construction-integration model, the reading process combines a simultaneous iteration of the bottom-up construction processes of building a propositional network based on text content with the top-down integration processes based on inferences enabled by the reader's knowledge. However, both reading activities themselves as well as the assessment of reading literacy have undergone substantial mode changes in recent years through the shift from paper-based to digital-based.

Reading literacy and its assessment on digital devices can entail two systematically different concepts (see Naumann & Sälzer, 2017; cf. OECD, 2016): It can take one of two forms: (a) It can take a text and text comprehension questions that were previously presented on paper and present them as similarly as technically possible on a digital screen without any functionality differing from a book (focus on mode change; *reading digitally*). (b) It can incorporate reading in digital environments (*digital reading*) with different tasks and challenges to those in paper-based reading (e.g., navigating; finding, selecting, and understanding information efficiently out of a choice of multiple websites; comprehending animated graphics). At least in part, digital reading constitutes a different construct of reading literacy, because it requires a specific process in which text comprehension and the operation of digital environments intersect in what is often referred to as "navigation" (Delgado, Vargas, Ackerman, & Salmerón, 2018). To avoid confounding change of mode with change of content (new task characteristics), the current article focuses on the first concept: reading on digital devices as a rather pure mode change from paper-based reading to digital based reading. Because so much reading acquisition and development is now taking place digitally, it is important to investigate which features of the new mode and which student characteristics predict reading digitally.

Most children acquire reading systematically in elementary school. Different theoretical models describe various stages of children's learning to read (for alphabetic systems such as German, see, e.g., Frith, 1985). They all include the need for children to understand the connection between a (written) sign and the sound it is assigned to, and the ability to connect various sounds to an entire word that, at an advanced stage, takes the form of orthographic reading of whole units. Additionally, and in turn, the decoded word and, at a later stage, entire sentences, paragraphs, and texts then need to be related to their meaning. During the first years of schooling, most children make great progress in automatizing their decoding skills and thus their reading literacy. Typically, students start to read fluently in 2nd- or 3rd-grade (see Chall, 1983). This automatization allows them to focus their cognitive resources on the content rather than on decoding. In her five-stage model, Wolf (2008) states that roughly 9 years is the age of moving from *the decoding reader to the fluent, comprehending reader*. This transition is of vital importance to children's further educational paths, because this period of their schooling marks the shift from *learning to read to reading to learn*. Reading turns from being an educational goal itself to being mostly an educational tool or even an educational prerequisite. Thus, it is no surprise that not only international but also many national educational monitoring studies focus on assessing reading literacy in this age group.

On an international level, the *Progress in International Reading Literacy Study* (PIRLS) is investigating elementary school students' reading literacy (International Association for the Evaluation of Educational Achievement (IEA), 2015; for older students, see Program International Student Assessment (PISA), OECD, 2016). In 2016, Germany's 4th-grade students, who are mostly at the end of their elementary schooling, attained a lower middle ranking in the international comparison, but this was not significantly lower than the mean score for all EU countries or all OECD countries (Hußmann et al., 2017). However, a major concern was the systematic differences among subgroups of students and, in particular, the lower average performance of students with a less privileged socioeconomic background, of students with a migrant background, and of boys compared to girls (Hußmann et al., 2017).

In the long-term perspective from 2001 to 2016, there has been no significant change in 4th-grade students' reading achievement in Germany. However, up to now, this has been assessed continuously with paper-based tests. In 2021, the PIRLS assessment will become digital. This mode change raises questions on the validity of any comparisons with previous paper-based assessments (e.g., Zehner, Goldhammer, Lubaway, & Sälzer, 2018). Whereas there is a quite large body of research on digitalization for older students and adults, it is still largely unclear how younger students handle working on digital devices during assessments in the domain of reading; and whether, for example, motivational aspects regarding working on digital devices relate to proficiency scores – either for all students or potentially even differentially for different subgroups of students.

2.2 Digitalization of children's environment, reading on digital devices, and paper versus digitally based reading

The increasing inclusion of digital devices in children's lives and particularly in their learning environments is an everyday reality. In a recent meta-analysis, Delgado et al. (2018, p. 36) concluded that "it is clear that digital-based reading is an unavoidable part of our daily lives and an integral part of the educational realm." In a German sample of 10- to 11-year-old children, 67 % reported owning a smartphone and 32 % a tablet; and in a sample of 12- and 13-year-olds, 87 % at least sometimes used a smart phone and 58 % a tablet (BitKom Research, 2017, pp. 2–3). Six- to 13-year-old students named digital games, internet, and smartphone usage more often as their favorite leisure-time activity than reading a book, and more than one-half used the internet at least once a week (Medienpädagogischer Forschungsverbund Südwest, 2016).

Due to increased access to and use of digital devices, substantial changes have also been observed in children's reading habits: Reading is now frequently performed with digital screen technologies such as laptops or tablets and e-readers (e.g., Clark, 2011; Duncan, McGeown, Griffiths, Stothard, & Dobai, 2016). Moreover, the role of digital devices (e.g., computers, tablets, e-books, and smartphones) as reading tools for and within education is also increasing substantially, because schools worldwide are beginning to shift to digital classrooms. In the last PIRLS assessment, German 4th-grade students reported using computers or tablets for 10 to 30 minutes a day to obtain information for school or to prepare texts or presentations (Hußmann et al., 2017). In contrast to the increasing use of digital devices, a comparison between 2001 and 2016 revealed that fewer students read books daily (Goy, Valtin, & Hußmann, 2017). Unfortunately, evidence on the relation between reading literacy and digital media use is inconclusive (Rosén & Gustafsson, 2016). Moreover, as well as digital devices being used either as tools for or as a target of learning, high stakes tests are increasingly being delivered digitally. The same trend can be observed in the large-scale international student assessments such as PIRLS or PISA.

The fundamental change from exclusively paper-based reading to reading in a multimedia world raises a number of theoretical as well as empirical questions (Mangen & van der Weel, 2016). Concerning the question of equivalence of computer versus paper-based tasks, Dillon (1992) reported in an earlier literature review that speed, accuracy, and comprehension were generally worse when assessed digitally. Building on this work, Noyes and Garland (2008) summarized their review results as showing mixed evidence regarding equivalence. They suggested that analyses should include further indicators such as cognitive workload and preferences. The authors concluded that although some tasks will never be equivalent, greater equivalence is being achieved today due to the general changes. Wells (2012) randomly assigned 140 middle and high school students to either a tablet or a paper condition when reading and answering comprehension questions. Fifty-four of the students also answered the MRQ (*Motivations for Reading*

Questionnaire). He found no differences between the two experimental groups in either reading comprehension or reading motivation. In contrast, a very recent meta-analysis examining research from 2000 to 2017 found that digital environments are not always best suited to foster competence development and deep comprehension in the domain of reading (Delgado et al., 2018). Both between- and within-participant designs produced the same results showing advantages of paper over digital reading. This advantage increased in time-constrained reading conditions and with recency of publication year, and was not found in studies using only narrative texts. The authors concluded that providing students with printed reading material might be a more effective way to improve comprehension. Overall, these studies could be interpreted as indicating that the change of reading habits to an increased use of digital devices is related to a lower level of reading comprehension on screen due to particular digital characteristics. However, this does not answer the question whether the change in reading habits toward more digitally based reading is leading to an overall decrease in reading competence.

Another strand of research that might add relevant information on the significance of the reading medium and the potential change in reading literacy levels is mode effect studies in the field of psychometrics. After transitioning from paper- to digital-based assessments, the OECD acknowledged the possibility that small to medium mode effects in PISA 2015 might have led to lower student scores (OECD, 2016). For Germany, Robitzsch et al. (2017) investigated the mode effect due to change in mode and tasks; and Zehner et al. (2018) examined the effect of changing the mode on open-ended tasks. Both research teams found only small effects with computer-based reading tasks being slightly more difficult compared to paper-based ones. These results might indicate that reading and reading digitally are somewhat different constructs. However, international assessments have not just changed the mode but also adapted tasks to take advantage of the new technical possibilities (digital reading). Empirical evidence on the comparability of paper-based reading and reading digitally is still scarce for German elementary school students. Singer and Alexander (2017, p. 2) pointed out that we still have only a limited understanding of how certain attributes of, for example, the learner (as well as the text, or the context) “might interact with the [reading] medium to enhance or inhibit comprehension.” One important student characteristic to consider when investigating reading and comprehension is gender.

2.3 Reading and gender

Gender is a frequently analyzed predictor of reading (Logan & Johnston, 2010; for gender differences and similarities in general, see Hyde, 2014; for gender and educational outcomes, see Steinmayr & Spinath, 2008). Concerning reading literacy, girls had a higher average achievement than boys in 4th-grade in Germany – as in all other countries included in PIRLS 2016 except Macao SAR and Portugal. Girls outperformed boys especially in literary reading literacy (in Germany: 18

points; McElvany et al., 2017). The difference was notably smaller (5 points) for informational reading literacy. Examining gender differences for older students, PISA data showed that the gender gap between 15-year-old girls and boys was even more substantial. Nonetheless, whereas the German difference in reading in PISA was 40 points in 2009 and 44 points in 2012, it fell to 21 points in 2015 (Weis et al., 2016). One possible explanation for these changes and in particular for the decrease in reading is the change in PISA assessment mode that occurred between 2012 and 2015 with the previous paper-based assessments being replaced by computer-based assessments. Moreover, with respect to the younger age group, a decrease in the gender gap was observed in several of the countries participating in ePIRLS (Mullis et al., 2017). For example, Danish students exhibited a significant gender gap in the paper-based PIRLS 2016, but no such difference between boys and girls in ePIRLS. These results are in line with previous research indicating that gender differences in reading depend in part on features of test construction (e.g., Solheim & Lundetrae, 2018).

In addition to the gender gap found in reading literacy, both reading and digital habits have been reported to differ substantially between boys and girls. Gender-specific reading preferences can be observed for both traditional reading materials (e.g., Clark, 2011) and digital reading materials (Duncan et al., 2016). In Duncan et al.'s (2016) study, gender effects favoring female students were evident for both paper-based and digital reading frequency. However, Colley and Comber (2003) found that boys used computer technology more frequently in out-of-school contexts than girls. Concerning the nature of digital activities, Ofcom (2012) reported that girls were more likely to use the internet for homework, visiting social networking and other websites, instant messaging, and Twitter, whereas boys were more likely to use it to play games or watch video clips.

This observation reveals the need to ask which mechanisms impact on potential gender differences in reading digitally. Although there is little research on gender differences in reading digitally, there are many arguments explaining gender differences in reading in general. However, evidence on most of these arguments is rather weak (e.g., cognitive differences, feminization of school, teaching methods used; see Solheim & Lundetrae, 2018), although there is frequent empirical support for the argument that boys and girls differ in their reading motivation (e.g., Schwabe, McElvany, & Trendtel, 2015).

2.4 Predictor of reading literacy: Role of motivation

Reading motivation can be defined as “the drive to read for internal purposes, such as deriving pleasure, attaining personal goals, or satisfying curiosity” (Conradi, Jang, & McKenna, 2014, p. 154). Many empirical studies have reported that girls are significantly more highly motivated to read than boys (elementary school students: Becker & McElvany, 2017; secondary school students: Brozo et al., 2014). Additionally, male students' reading motivation tends to relate more closely to

the level of their reading performance (Solheim & Lundetrae, 2018). McGeown et al. (2012) have provided an important clarification on understanding these differences by showing that students' intrinsic motivation is explained better by gender identity than by sex. The socially perceived femininity of the reading domain was also supported by results of their study indicating that a feminine identity is more closely related than a masculine identity to various aspects of reading motivation.

These mechanisms lead to another important predictor of reading literacy: the reading self-concept. The reading self-concept is "an individual's overall self-perception as a reader, including one's sense of competence and the role ascribed to reading as a part of one's personal identity" (Conradi et al., 2014, p. 154). In contrast to reading motivation, empirical evidence regarding gender differences in reading self-concept is heterogeneous and indicates either no gender gap or an advantage for girls (Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002; for Germany, see Becker & McElvany, 2017).

Recently, analyses of the German PIRLS data have reconfirmed the important role of motivational variables in explaining gender differences in reading: After controlling for reading motivation, reading behavior, and reading self-concept, the effect of gender on reading literacy was no longer statistically significant (McElvany et al., 2017).

Gender differences in motivation also exist for reading digitally (see McGeown et al., 2016). In a sample of 791 elementary students, intrinsic and extrinsic motivational facets predicted systematic differences between boys and girls in their frequency of reading both traditional reading materials (i.e., factual and fiction texts) and digital reading sources (i.e., communicative digital texts). However, the authors had used the MRQ, and they themselves stated that this instrument was not perfectly suited to study motivational dynamics with respect to nonbook reading, because it had not been developed to study the motivation for reading, for example, magazines, comics, and digital texts. Hutchison, Woodward, and Colwell (2016) reported multiple gender differences in a study of more than 1,000 4th- and 5th-grade students. For example, male students preferred using the internet over reading a book, whereas female students preferred reading a book. In addition, males assumed that they would learn more from using the internet than from reading a book. Furthermore, more boys than girls considered it to be more difficult to read a book than to watch TV, whereas more girls considered it more difficult to use the internet than to read a book. International ePIRLS results supported the relevance of motivational variables for successful online informational reading. Level of self-efficacy with respect to, for example, using computers was related to average achievement. For 15-year-olds, data from PISA 2009 revealed that online reading engagement, which was conceptualized as including reading motivation as well as a positive attitude toward usage of digital devices, predicted online text reading competence even after controlling for reading competence (Naumann, 2013).

The current mode change also focuses attention on other motivational aspects: boys' and girls' motivation to handle digital devices and also their digital self-concept. One frequently formulated explanation is that boys enjoy digital devices

more; and this, in turn, is assumed to encourage achievement when working on digital tasks (Martin & Binkley, 2009). This claim seems to be supported by studies showing that males have more positive attitudes toward technology and computers than females (see also the previously reported differential use of digital technology). For example, studies have revealed that males like using computers more than females and that their self-concept of their ability to use computers is higher (Colley & Comber, 2003). For the German ICILS 2013 sample, Lorenz et al. (2014) reported gender differences in ICT self-efficacy for advanced computer skills. In a recent meta-analysis, Cai, Fan, and Du (2017) revealed that the gender gap in attitudes toward digital devices persists even though digital devices are part of everyday life in Western societies. But Cai et al. (2017) also reported that both genders exhibit mainly positive attitudes toward digital devices, indicating that test performance across modes might not be a question of liking digital devices. This is in line with Punter, Meelissen, and Glas (2017) who observed that 14-year-old girls outperformed boys in computer and information literacy skills in most countries participating in a recent large-scale survey. This finding contradicts the expectation that the more positive attitudes among males compared to females would lead to better results on computer-based tests, as assumed by, among others, Martin and Binkley (2009).

Most past research on reading, especially on reading by children, has focused on paper-based reading. Furthermore, the motivational dynamics have not yet been studied by including the aspect of motivation toward working with digital devices. Because both the children's environment and the modes of test taking are changing from paper-based to digital, it is necessary to reconsider theoretical assumptions on relevant predictors of reading and to empirically test the relevance of both established and new constructs.

3. Research aims

In light of the increasing importance of digital devices not only in everyday life but also for learning and assessment in schools, the present study focused on the gender gap in reading to be found in digital assessments of reading competencies. In addition, we were interested in whether motivational aspects related (a) to working with digital devices and (b) to reading in general predict reading digitally and whether the motivational characteristics related to digital devices differ between boys and girls. Finally, we examined whether the motivational constructs mediate the relation between gender and reading digitally. In concrete terms, we explored the following research questions:

1. Is there a gender gap in the competence of reading digitally at the end of elementary school?

2. Do motivation and the self-concept with respect to (a) working with digital devices as well as (b) reading in general predict the competence of reading digitally?
3. Do motivation and the self-concept with respect to working with digital devices differ between girls and boys?
4. Do the motivational variables involved in (a) digital devices and (b) reading in general mediate the relation between gender and the competence of reading digitally?

Combining theoretical lines of research on the advantages of girls in the reading domain, we expected to find a gender gap in the competence of reading digitally in favor of girls (Hypothesis 1). Moreover, due to the theoretical relevance of motivation and the self-concept for achievement, we expected motivation and the self-concept with respect to working with digital devices (Hypothesis 2a) as well as motivation and the self-concept with respect to reading in general (Hypothesis 2b) to be statistically significant predictors of the competence of reading digitally after controlling for gender. Whereas gender differences in reading motivation and the reading self-concept have been investigated comprehensively, little is known up to now about potential gender differences in working with digital devices at elementary school age. Due to conflicting theoretical arguments pointing to advantages for girls when reading is highlighted and advantages for boys when digital devices are stressed, we did not formulate any hypothesis for our third research question. Finally, in light of the expected relevance of motivational aspects for reading along with gender differences in the motivational constructs, we expected that motivational variables and, in particular, the aspect of reading motivation would mediate the direct path from gender to reading digitally (Hypothesis 3).

4. Method

4.1 Participants

Data was gathered in 2017 within the research project *Faire und Adaptive Lesekompetenzdiagnose* (FALKE). A sample of 604 fourth-grade students from 37 classrooms at 21 schools took part in the assessment. Six students were excluded from the analysis because they did not take part in the digital assessment of reading competence. The students' average age was 10.29 years ($SD = 0.45$) and 51.0 % were female. Data were collected in a large urban region of Germany. We assessed socioeconomic background with the *Highest International Socio-Economic Index of Occupational Status* (HISEI; Ganzeboom, de Graaf, & Treiman, 1992). The sample was fairly typical for the HISEI in Germany ($M = 50.97$, $SD = 19.87$ compared to the HISEI of a representative sample in 2016 of $M = 50.6$, $SD = 20.7$; see Stanat, Schipolowski, Rjosk, Weirich, & Haag, 2017). Twenty-two percent of

the students reported not speaking solely the language of the reading test at home. Gender groups did not differ with respect to HISEI, percentage of students with a migrant background, or age.

4.2 Instruments

Students worked on digital reading items with single multiple-choice questions on each short text (32 to 110 words each; Schwabe & McElvany, 2013). Due to the multimatrix design, not every student worked on the same booklet. Each student worked on 27 to 30 reading test items within 30 minutes. The items were presented on tablets. Students were asked to select the correct answer among four options. Texts and questions covered factual and nonfactual texts as well as lower- and higher-level reading processes. Responses were used to scale the items in an IRT framework. Item difficulties and person parameters were gathered from a 1PL model using the software package TAM (Robitzsch, Kiefer, & Wu, 2018) implemented in R. Person parameters were scored on a metric with 0 as mean and 1 as standard deviation. EAP reliability of the test was satisfactory ($EAP_{WLE} = .78$). Moreover, the test showed substantial correlations with an established standardized paper-based test of reading competence ($r = .60$; $p < .05$).

Motivational student characteristics in the domains of working with digital devices as well as reading in general were assessed with paper-based questionnaires. The reading motivation and reading self-concept scales were originally developed in the project *LESEN 3-6* conducted in Berlin by the Max Planck Institute for Human Development (see Becker et al., 2010). The items for working on digital devices were specially constructed for this study. Whereas the self-concept items were parallel versions of the reading self-concept measure, the items on motivation for working on digital devices were adapted from a scale used in the BIJU study (*Bildungsverläufe und psychosoziale Entwicklung im Jugend- und jungen Erwachsenenalter*; Baumert et al., 1997). For ease of presentation, we label the constructs *motivation/self-concept for working on tasks on digital devices* in the following as *digital motivation/self-concept*. The correlation pattern for the domains and constructs supported the validity of the newly constructed scales (see Table 2). Additionally, the digital motivation scale correlated moderately with digital reading behavior ($r = .40$) and the digital self-concept scale correlated highly with digital self-efficacy ($r = .72$), thereby supporting the scales' convergent validity. All scales contained four items to be answered on 4-point scales ranging from 1 (*do not agree*) to 4 (*agree totally*). Descriptive information and examples of items are reported in Table 1. Reliabilities were acceptable to good for all scales.

Table 1: Scales, examples of items, descriptive statistics, and reliabilities

	Examples of items	<i>M (SD)</i>	α
Digital motivation	I enjoy working on digital devices	2.76 (0.73)	.65
Digital self-concept	Working on digital devices is easy for me	2.93 (0.64)	.64
Reading motivation	I like to read	3.28 (0.79)	.77
Reading self-concept	Reading is easy for me	3.17 (0.70)	.82

Note. Original German items translated by the authors.

4.3 Analytical strategy

Data were analyzed with Mplus 7 (Muthén & Muthén, 1998–2012). Missing data, which ranged from 4.0 to 11.2 %, were estimated with the *Full Information Maximum Likelihood* (FIML) method. We applied Type = complex to correct for the nested data structure in all models specified. We decided to perform one-level analyses, because we assumed the underlying processes to be more important on an individual rather than a group level. Indeed, the intraclass correlation coefficients (ICC) of all variables were no higher than .07.

To answer the four research questions, we specified regression (Question 1) and structural equation models (SEMs; Questions 2 to 4). For the motivational variables, we used the answers to the items as indicators of latent constructs, while including reading competence and gender as manifest variables. The mediation model included both indirect paths from gender via motivational variables to reading competence and direct paths from gender and motivational variables to reading competence. Intercorrelations between dependent variables (Question 2), predictors (Question 3), mediators (Question 4), and individual error terms were allowed. All reported coefficients were standardized. The model fit was evaluated on the basis of CFI, RSMEA, and χ^2 .

5. Results

5.1 Preliminary analyses

Whereas mean scores on digital motivation and self-concept ranged between 2.5 and 3, indicating a slightly positive level, expressions of reading-related constructs were generally positive. Bivariate correlations between the constructs of interest are presented in Table 2.

Table 2: Bivariate manifest correlations

	Reading score	Digital motivation	Digital self-concept	Reading motivation	Reading self-concept
Reading score	1.00	–	–	–	–
Digital motivation	-.10*	1.00	–	–	–
Digital self-concept	.08	.33*	1.00	–	–
Reading motivation	.25*	-.09*	.06	1.00	–
Reading self-concept	.27*	-.06	.28*	.43*	1.00

Note. * $p < .05$.

Except for digital self-concept, all motivational variables showed statistically significant bivariate correlations with the reading score. The correlation between digital motivation and the reading score was small and negative. Correlations between the motivational constructs were significant and positive for both reading and digital devices, with the highest correlation being found between reading motivation and reading self-concept. Across domains, self-concepts correlated positively, whereas reading motivation correlated negatively with digital motivation ($r = -.09$). No significant correlations were found between different domains and different motivational constructs.

5.2 Gender differences in reading digitally

To answer the first research question, we specified a regression model with competence of reading digitally as dependent variable and gender as predictor (saturated model: CFI = 1.00, RMSEA = 0.00). Being female predicted reading digitally positively ($\beta = .09$, $SE = .04$, $p < .05$). The size of the standardized regression coefficient was rather small. Comparing the average reading competence of girls with that of boys revealed a medium effect size of Cohen's $d = 0.45$. In sum, data supported the expected gender gap in favor of girls in reading digitally in line with Hypothesis 1.

5.3. Predicting reading digitally by digital and reading-related motivation and self-concept

To examine the second research question, we specified a SEM with reading digitally as dependent variable, motivational aspects of students with respect to (a) digital devices and (b) reading as predictors, and gender as control variable. The model fit was acceptable ($\chi^2 = 237.77$, $df = 102$, $p < .05$, CFI = .94, RMSEA = .05).

Table 3: Path coefficients from SEM predicting digital reading by motivational variables

	β	<i>SE</i>	<i>p</i>
<i>Digital</i>			
Digital motivation	-.13	.10	.24
Digital self-concept	.06	.10	.58
<i>Reading</i>			
Reading motivation	.12	.06	< .05
Reading self-concept	.24	.08	< .05
Female	.02	.04	.60
<i>R</i> ²	.13		

Note. Significant intercorrelations between predictors: digital motivation with digital self-concept: $r = .67^*$; reading motivation with reading self-concept: $r = .58^*$; digital self-concept with reading self-concept: $r = .26^*$.

* $p < .05$.

Motivational variables predicted 12.5 % of the variance in competence of reading digitally in 4th-grade students (see Table 3). Neither digital motivation nor self-concept predicted reading digitally. Reading-related motivation and self-concept were statistically significant predictors of reading digitally. When the motivational constructs were included in the model, gender was no longer a statistically significant predictor of reading digitally. To summarize, the results on students' reading digitally competence were not affected by motivational variables relating to working on digital devices. In contrast, students' performance was predicted in part by reading-related motivational variables.¹ Therefore, Hypothesis 2a was rejected, whereas Hypothesis 2b was supported by the data.

5.4 Gender differences in digital motivation and digital self-concept

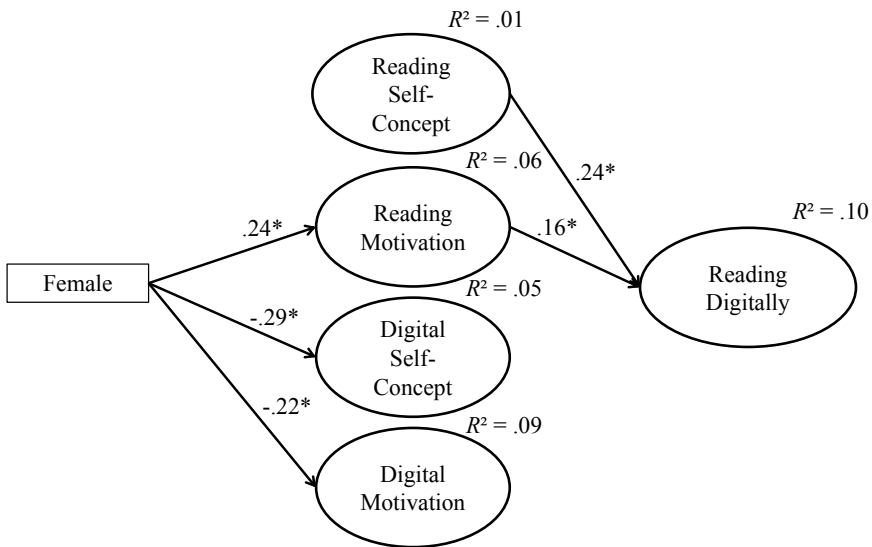
To investigate the third research question, we specified a SEM that included direct paths between gender and motivational aspects of students with respect to digital devices. The model fit was acceptable ($\chi^2 = 51.05$, $df = 16$, $p < .05$, CFI = .95, RMSEA = .06) and revealed significant paths between gender and digital motivation ($\beta = -.27$, $SE = .05$, $p < .05$) and between gender and digital self-concept ($\beta = -.19$, $SE = .04$, $p < .05$). The amounts of explained variance were rather small (digital motivation: $R^2 = .07$; digital self-concept: $R^2 = .03$). Girls possessed less positive motivation and self-concept in the digital domain compared to boys. Therefore, the data indicated a difference between boys and girls in digital motivation and self-concept.

¹ The pattern was robust when gender was not included.

5.5 Mediation of gender differences in reading digitally by motivational variables

To answer the final research question on whether motivational aspects with respect to (a) digital devices and (b) reading mediated the relationship between gender and reading digitally, we specified a SEM. This model included direct paths between reading digitally and both gender and motivational aspects of students with respect to digital devices. In addition, indirect effects of gender on reading digitally were specified via motivational aspects (see Figure 1). The model fit was acceptable ($\chi^2 = 200.00$, $df = 91$, $p < .05$, $CFI = .95$, $RMSEA = .05$).

Figure 1: Mediation model



Note. Indirect path from gender via reading motivation to reading digitally: .04*; Significant correlations between: digital motivation and self-concept: $r = .65$; reading motivation and self-concept: $r = .57$; digital and reading self-concept: $r = .23$.
* $p < .05$

The mediation model revealed that the gender gap in reading digitally was mediated fully by reading motivation. Alongside the statistically significant and substantial direct paths from gender to reading motivation and from reading motivation to digital reading, there was a statistically significant indirect effect (see Figure 1). All other motivational variables did not mediate the gender gap: Gender had no direct effect on students' reading self-concept, which was a positive predictor of reading. Again, gender had a statistically significant negative relation to digital motivational variables, but these had no direct effects on reading digitally. In sum, Hypothesis 3 was supported by the data on reading motivation.

6. Discussion

Reading is a core competence for lifelong learning. However, digitalization has led to fundamental changes in the ways information and texts are delivered (Mangen & van der Weel, 2016; see also political statements on digital media education as a new goal of education in Kultusminister Konferenz (KMK), 2016). This indicates the need for comprehensive knowledge on reading digitally. Because the end of elementary schooling is a crucial time point in reading development, the current study focused on reading digitally in younger students. Students' gender was at the center of the investigation, because, on the one hand, girls are known to be more motivated readers (e.g., McElvany et al, 2017), whereas, on the other hand, boys are often expected to hold more positive attitudes toward digital devices (Cai et al., 2017). We wanted to know how these conflicting aspects would play out empirically when *reading digitally* is measured.

The analyses revealed a statistically significant gender gap in reading digitally for 4th-grade students. Further analyses showed that reading digitally was substantially predicted by reading-related motivation and self-concept but not by digital motivation and self-concept. In addition, gender differences were found in digital motivation and self-concept, with boys possessing more positive values. Finally, the analyses pointed to the mediating role of reading motivation for the gender effect on reading digitally that was not found for any of the other motivational facets.

Thus, our study confirms that the girls' advantage also applies to reading digitally. This gender gap in reading digitally is in line with previous paper-based (e.g., McElvany et al., 2017) or digital (e.g., Mullis et al., 2017) findings for this age group. Our findings add to this body of research by focusing explicitly on the change from paper to tablet without any change in the items themselves. Moreover, our results suggest that gender-related differences in reading do not vanish as a result of digitalization. Quite on the contrary, it is new aspects such as motivation and self-concept in respect to working on digital devices that differ between boys and girls. Our observation of lower levels of digital motivation and self-concept in girls is in line with previous research on older students. For example, results from the ICILS 2013 showed lower self-efficacy on challenging ICT tasks in girls (Lorenz et al., 2014). Moreover, this observation relates to the well-known STEM gender gap (e.g., Liben & Coyle, 2014).

The lack of a relation between either digital motivation or between digital self-concept and reading digitally provides very important information for test developers, test takers, educators, and educational administrators. Our study provides first evidence that digitally based testing of reading competence is already possible in grade 4 without confounding the reading results with construct-irrelevant influences of motivational aspects related to the test mode *digital*. Nonetheless, this pattern of results needs to be replicated in larger student samples. Furthermore, results on the reading-related motivation variables predicting reading digitally can be interpreted on the basis of comprehensive theoretical work and previous em-

irical evidence as supporting the content validity of testing reading digitally. This result differs somewhat from findings on digital reading in which digital reading engagement was found to predict digital reading competence (Naumann, 2013). Hence, a *mode-only* change might not alter the construct of reading.

Finally, the present results are in line with research on the crucial significance of intrinsic reading motivation for reading competence (Becker & McElvany, 2017; Brozo et al., 2016). Our findings contradict recent findings from McGeown et al. (2016), who reported no relation between intrinsic motivation and the amount of digital reading, which might be a proxy for reading competence. The differences in results might stem from the usage of different measures of intrinsic reading motivation. Our broader measure of reading motivation does not explicitly exclude reading digitally or digital reading from the reading construct.

Due to the cross-sectional design of our study, we cannot interpret our findings causally. Moreover, the newly constructed measures of digital motivation and self-concept fail to show very good reliabilities in this young age group. Hence, more research is needed to replicate the findings reported here.

Future studies could follow up on the gender gap and use a parallel administration of the same test items in both modes to investigate how the size of the gender gap reported here relates to the gender gap in a paper-based test (see for older students, Zehner et al., 2018). Future studies could also include reading behavior with both traditional and digital materials. This might shed light on the mechanisms underlying the link between reading motivation and reading digitally. Also more specifically the construct of *digital reading motivation* could be investigated.

Our study raises several issues: We focused on gender as an important individual predictor. Looking at social predictors, especially in Germany and in many other Western countries, social status relates closely to reading competence (e.g., Hußmann et al., 2017). Differential availability and, furthermore, differential use of digital devices as well as familiarity with reading (informational) texts on digital devices might influence coping with demands of reading digitally in educational and testing situations. Therefore, for example, socioeconomic status seems to be an important aspect to consider when investigating reading digitally as well as digital reading.

Our particular interest was in an achievement test of reading digitally. However, the investigation also provides important insights for educational practice. Whereas the gender gap in reading digitally is itself obviously a matter of concern for educators, boys' higher motivation for digital devices might, at the same time, offer a starting point for effective support measures. Because elementary school students currently report that their out-of-school environment is involved much more strongly with digital media than their school learning environment, increasing interesting and effective ways to use digital devices might help boys to further advance their reading digitally (see also Delgado et al., 2018). Thus, more research will be needed on how and when digital devices can be included productively in not only assessment but also learning. For example, a recent study using a randomized controlled trial showed that a computer-assisted reading program such as

Accelerated Reader had a statistically significant positive impact on student reading gains when compared with traditional reading instruction (Shannon, Styers, Wilkerson, & Peery, 2015). At the same time, the generally low student motivation regarding working on digital devices indicates the need for good concepts to prepare elementary school students for the growing digitalization of their educational environment. In particular, the low motivation in girls requires attention and calls for an awareness for gender-sensitive approaches.

The results presented here provide important information on the substantial changes in the context of reading in the 21st century. Because reading is of such fundamental relevance on both the individual and the societal level, it is very important for modern societies to analyse and understand these changes.

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