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ORIGINAL PAPER

The digital home learning environment and its relation to children's ICT self-efficacy

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Abstract
With the rapid progress of technological development, self-efficacy in reference to digital devices (i.e., information and computer technology [ICT] self-efficacy) is an important driver that helps students to deal with technological problems and support their lifelong learning processes. Schools, peers, and home learning environments are important sources for the development of positive self-efficacy. Expanding on previous research, we investigated the associations between different aspects of the digital home learning environment and students' ICT self-efficacy. The moderation effects of gender were also tested. A total of 651 children answered a questionnaire about different digital home learning environment dimensions and estimated their ICT self-efficacy using an adapted scale—Schwarzer and Jerusalem's (1999) general self-efficacy scale. Using the structural equation modeling technique, a digital home learning environment containing six different qualities of parental support was investigated. Families' cultural capital, parents' attitudes toward the Internet, and shared Internet activities at home contributed positively to ICT self-efficacy. We observed small gender differences, with the moderation effect being nonsignificant. The results help researchers and practitioners to understand how different dimensions of the digital home learning environment support ICT self-efficacy. We will discuss how parents can enhance the home learning environment and how teachers can integrate this knowledge into formal education.

Keywords Digital media use · Gender · Home learning environment · ICT self-efficacy · Motivation · Parental involvement

Introduction

Motivational attitudes, such as self-efficacy, are important predictors of students' academic success and development (Eccles, 2007). Because of the ever-increasing integration of new technological devices into the classroom and the use of information and computer technology (ICT) for learning (Kumpulainen et al., 2018; Lewin & Charania, 2018), ICT-specific

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self-efficacy is an important driver that helps students to deal with technological progress, supports lifelong learning processes, and could become as important as competencies and skills (Senkbeil & Ihme, 2017; Warschauer & Xu, 2018). When students feel more self-confident about dealing with new technologies, they are more able to solve upcoming problems, are prepared to use ICT for learning in school, and are more willing to enhance their ICT skills during their whole life (Hatlevik et al., 2018; Senkbeil & Ihme, 2017).

Students' experiences in different learning environments, such as school, home, or peer group, are important sources of self-efficacy development (e.g., Khine et al., 2020). It was reported that students' ICT use at home was still higher than ICT use at school (Eickelmann et al., 2014). Furthermore, students' experiences with ICT at home seemed to be more important for the development of ICT self-efficacy than their experiences in other learning environments (Aesaert & van Braak, 2014; Hammer et al. 2021). This result is rather atypical for learning environments research, which has pointed out the pivotal role of the classroom environment (e.g., cooperation, student cohesiveness, and teacher support) for the development of other cognitive and noncognitive outcomes (Khine et al., 2020). Regarding these results, the present study's aim was to undertake a more in-depth examination of the contribution of the home learning environment (HLE; Bradley & Corwyn, 2005) to self-efficacy in the field of ICT.

In addition, to HLE as a precursor to self-efficacy, gender has been controversial in regard to the differences in ICT self-efficacy (Siddiq & Scherer, 2019). Even though we know much about gender differences in ICT self-efficacy and parental mediation styles, little is known about the socialization of ICT self-efficacy when gender is taken into account (Rohatgi et al., 2016). Therefore, the second research question deals with the moderating effects of gender on the relationship between family determinants and ICT self-efficacy.

The results provide suggestions for parents and teachers about creating a positive and enriched learning environment and extending the former research on HLE, which mainly looked at parents' strategies concerning the prevention of children's Internet risks (Livingstone et al., 2017). In the following sections, we describe the importance of self-efficacy in the context of ICT. Building on this, we adapt the HLE framework and differentiate several dimensions of HLE in the digital age before deriving our hypotheses concerning the relationship between digital HLE and ICT self-efficacy.

Self-efficacy and ICT self-efficacy

Self-efficacy can be defined as a person's beliefs about his or her abilities to perform a specific behavior successfully (Multon et al., 1991). Bandura (1977) introduced self-efficacy as an individual factor that influences one's choice of activities, persistence in conducting the activity, and task performance. Therefore, it influences students' academic achievement during their schooling. Meta-analyses have shown a positive medium effect size of self-efficacy for persistence and performance in academic contexts (Multon et al., 1991; Schunk et al., 2012).

We investigated self-efficacy in the context of ICT. Previous studies distinguished between two different forms of ICT self-efficacy: a more general computer self-efficacy and a specific Internet self-efficacy. Internet self-efficacy comprises operations such as retrieving and processing appropriate information (Aesaert & van Braak, 2014; Eastin & LaRose, 2000). In this study, ICT self-efficacy is defined with regard to the ICILS (International Computer and Information Literacy Study) definition of computer and information literacy

(CIL; Fraillon et al., 2014). Regarding ICILS 2013 and 2018, CIL "refers to an individual's ability to use computers to investigate, create, and communicate in order to participate effectively at home, at school, in the workplace and in society" (Fraillon et al., 2019, p. 16). Fraillon et al. (2014) described CIL by distinguishing between two strands. Strand 1—'collecting and managing information'–comprised three aspects: (1.1) knowing about and understanding computer use, (1.2) accessing and evaluating information, and (1.3) managing information. Strand 2—'producing and exchanging information'–comprised four aspects: (2.1) transforming information, (2.2) creating information, (2.3) sharing information, and (2.4) using information safely and securely. Our conception of ICT self-efficacy is based on strand 1 of CIL: collecting and managing information with a focus on its assessment, evaluation, and management (Fraillon et al., 2014). Therefore, ICT self-efficacy is operationalized as students' beliefs about their ability to successfully assess, evaluate, and manage information in the context of ICT. The definition comprises only strand 1, because the main ICT use at home–communicating and information sharing–falls into this strand (Fraillon et al., 2014; Rohatgi et al., 2016).

ICT self-efficacy, or special concepts such as Internet self-efficacy, is an important precursor of CIL (Hatlevik et al., 2015; Rohatgi et al., 2016; Senkbeil & Ihme, 2017; Wan et al., 2008). Regarding the ongoing integration of ICT use into the classroom, a deeper understanding of relevant factors that contribute to favorable ICT self-efficacy is crucial and enriches learning environments research. This understanding provides pivotal knowledge for teachers and parents to enable them to support students' learning with ICT at school and at home.

Home learning environment (HLE)

Students' actual performance and former experiences in different learning environments, such as school, home, or peers, are important sources that influence the development of self-efficacy in general (Schunk & Pajares, 2009). In addition to experiences with ICT that children can gather in the school environment (Khine et al., 2020), their experiences at home using ICT among others for recreational purposes seem to be pivotal (Hatlevik et al., 2018, p. 114): "When parents are involved in their children's school-related activities, provide encouragement, and express positive expectations, children are more likely to have good self-efficacy beliefs for school learning." Internationally, and especially in Germany, ICT use at home is still more frequent than ICT use in school (Aesaert & van Braak, 2014; Bundsgaard & Gerick, 2017; Eickelmann et al., 2014; Fraillon et al., 2014). Furthermore, in comparison to school factors (e.g., teacher attitudes toward ICT use in the classroom environment), HLE factors were more predictive for students' ICT self-efficacy (Aesart and van Braak 2014; Eastin & LaRose, 2000; Rohatgi et al., 2016; Zhong, 2011). This result is atypical of learning environments research and requires further examination. Because of the importance of home factors within the field of ICT, the present study examined more closely how the HLE contributes to ICT self-efficacy.

The HLE framework describes children's experiences in their homes and parental support at home in detail (Bradley & Corwyn, 2005). The important aspects of HLE can be summarized into five main categories (Bradley et al., 2019): (1) stimulation, which includes opportunities for exploration and learning; (2) instructions, referring to direct parental help, support, and guidance (e.g., during homework); (3) interactions, which include children's engagement in learning-stimulation activities, such as interactive

parent–child activities; (4) motivation, which reflects the ways in which parents comment on their children's school performance and refers to parents' expectations regarding this performance; and (5) modeling, which refers to parents' own behavior, as well as their attitudes and expectations regarding the development of their child. Stimulation and modeling can be classified as passive aspects of HLE, whereas instructions, interactions, and motivation are aspects of HLE in which children are interactively involved (Bradley et al., 2019; Wiescholek et al. 2018). To consider active and passive aspects equally, we focus on four of these five aspects: stimulation, instructions, interactions, and modeling.

Digital home learning environment (HLE)

Although there is a growing body of literature that recognizes HLE within the field of ICT, a systematic differentiation that provides an overview of several different dimensions is still missing. For example, Aesaert and van Braak (2014) defined the ICT-oriented home situation as the environment in which children grow up surrounded by digital media. The well-researched construct of parental mediation comprises parental strategies for regulating children's ICT use and reducing their Internet risks, as well as parents' attitudes toward their children's Internet use (Livingstone & Helsper, 2008; Livingstone et al., 2017). Using the HLE framework to systemize ICT use at home combines former results and brings new insights that fill an important gap in the field of learning environment research. We describe each aspect of digital HLE (stimulation, instructions, interactions, and modeling) in reference to the ICT context, as well as the relationships between each aspect and ICT self-efficacy.

Stimulation

Stimulation often was operationalized in ICT research as ICT access. In OECD (Organisation for Economic Co-operation and Development) countries, nearly every household is fully equipped with ICT. However, there is still a difference between computer access of the whole family and a child's own computer access; the latter means that the child possesses an individual computer in his or her own room. For example, 98% of children in Germany have access to a family computer, whereas only 65% possess an individual computer (Rathgeb & Schmid, 2019). However, differences in motivational attitudes, such as ICT self-efficacy and ICT literacy, are still present among families with high versus low cultural capital (OECD, 2015; van Deursen & van Dijk, 2014; Vekiri, 2010a; Warschauer & Xu, 2018).

Regarding the contribution of ICT access to ICT self-efficacy, some studies reported positive relationships (Tsai & Tsai, 2010; Zhong, 2011), while others found no significant correlations (Aesaert & Braak, 2014; Vekiri & Chronaki, 2008). In addition, in keeping with Bourdieu (1983), ICT research often uses the number of books at home as an indicator of cultural capital; small but significant associations with ICT self-efficacy were found (Hatlevik et al., 2018; Senkbeil & Ihme, 2017).

Instructions

Parental instructions during children's ICT use can be operationalized as parental support, which comprises activities and strategies that help children during ICT use (e.g.,

helping with problems when children ask for help or illustrating ideas concerning what children can do with ICT). In keeping with this explanation, parental support can be interpreted as a sensitive reaction to children's needs during ICT use. According to self-determination theory, the quality of parental support mostly fosters children's needs for autonomy and competence, which in turn contribute positively to their motivational beliefs, including their self-efficacy (Ryan & Deci, 2000). Small to large positive effects of this kind of parental support on ICT self-efficacy have been found (Senkbeil & Ihme, 2017; Vekiri & Chronaki, 2008; Vekiri, 2010a). In contrast to these findings, Aesaert and van Braak (2014) found no significant effects of parental support on ICT self-efficacy. Many studies measured parental support by examining a mix of items that reflect many different aspects of HLE and particular support. For example, parents' general attitudes toward children's ICT use have been combined into one instrument, together with setting ICT rules, parent–child ICT activities, and parental estimation of children's ICT literacy (Aesaert & van Braak, 2014; Vekiri & Chronaki, 2008; Vekiri, 2010a).

Parental instructions can also be operationalized as interrupting, restricting, or monitoring actions during children's Internet use (Livingstone & Helsper, 2008). Following this interpretation, parental instructions are comparable to control strategies, which were predominantly investigated in research on parental homework involvement. Parents' control strategies, for example, resulted in children's more-pronounced homework procrastination (Dumont et al., 2014). The HLE framework emphasizes that these aspects are different dimensions of parental instructions at home. Therefore, a more in-depth investigation of these different aspects might create a deeper understanding of parental instruction.

Interactions

Interactions were predominantly investigated in research on parental mediation using the construct of active co-use (Livingstone et al., 2017). Interactions comprise shared ICT activities, such as parents sitting next to the child using ICT, parents and children talking about ICT, or using ICT (e.g., the Internet) together to plan family activities. This research tended to focus on the relationship between active co-use strategies and children's Internet risks (Livingstone et al., 2017). Little published data include the relationship between parental instructions, parent–child ICT activities, and ICT self-efficacy. In these data, the important predictors of ICT self-efficacy included children's own experiences and parent–child ICT use at home (Hatlevik et al., 2018; Rohatgi et al., 2016).

Modeling

With regard to modeling, Aesaert and van Braak (2014) referred to parental values as parents' estimation of the relevance of ICT use. On the one hand, some parents believe that their children benefit from using ICT; this reflects a positive attitude. On the other hand, many parents believe that ICT use can be dangerous, which reflects a more-critical attitude (Kumpulainen & Gillen, 2020). In terms of indicators of the home situation, parents' positive attitude toward ICT use was significantly related to ICT self-efficacy (Aesaert & van Braak, 2014).

In summary, two difficulties have become apparent. First, to our knowledge, only one study to date has investigated more than two different digital HLE aspects: availability,

parental support, and parental attitude (Aesaert & van Braak, 2014). Second, 'parental support' was the most-used but also the most-fuzzy construct in investigating the relationship between digital HLE and ICT self-efficacy. Further research is needed to explain the influence of different digital HLE aspects on ICT self-efficacy. This research could lead to a deeper understanding of the development of ICT self-efficacy.

Gender differences

Gender differences regarding ICT use, self-efficacy, and competencies are discussed controversially (Hatlevik et al., 2018). There is a huge body of research on gender vis-à-vis ICT self-efficacy that shows that boys estimate their ICT self-efficacy higher than girls do (Hargittai & Shafer, 2006; Lorenz et al., 2014; Tømte & Hatlevik, 2011; Tsai & Tsai, 2010; Vekiri & Chronaki, 2008). Furthermore, research shows that gender differences in ICT self-efficacy depend on specific ICT activities. For example, relative to boys, girls reported higher self-efficacy regarding communicative Internet activities than for explorative Internet activities (Tsai & Tsai, 2010; Vekiri, 2010b). Additionally, in a German study, Lorenz et al. (2014) found no gender differences in self-efficacy regarding basal ICT literacy, but that boys reported higher self-efficacy regarding advanced ICT literacy.

In comparison with research on gender differences regarding ICT self-efficacy, less research has focused on the socialization background of gender differences regarding digital HLE. Only a few results can be summarized. Parental mediation research, for example, revealed that girls' parents expected a higher Internet risk to exist than boys' parents did (Livingstone & Helsper, 2008). Furthermore, Vekiri and Chronaki (2008) reported a stronger association between parental support and boys' Internet use compared with girls' Internet use. They investigated fifth and sixth grade students in Greece. Parental support was operationalized as children's perceptions of parental encouragement regarding computer activities. Rohatgi et al. (2016) investigated gender as a moderator of the association between different types of children's ICT home use and ICT self-efficacy. They distinguished between the use of ICT for task learning, which referred to ICT tasks at school, for study purposes and for recreation. The correlation coefficients between ICT self-efficacy and the use of ICT for task learning and recreation were higher for girls than for boys. In a recent study, Michell et al. (2018) investigated gender inequity in computer science and found that Australian students' interest in computer science was influenced in different ways by teachers, peers, and parents.

Beyond these individual and heterogeneous findings, only a small body of research has involved more than one aspect of digital HLE simultaneously. Although a growing body of literature recognizes the importance of digital HLE for the development of ICT self-efficacy, this study provides new insights by investigating the contribution of different aspects of digital HLE to ICT self-efficacy. Furthermore, although gender is an important predictor of ICT self-efficacy, it is rarely included in research as a moderator of the influence of digital HLE on ICT self-efficacy. Our study also addressed this desideratum.

Research model and hypotheses

This study aimed to investigate the contributions of four different process variables of digital HLE (stimulation, instructions, interactions, and modeling) to ICT self-efficacy. We addressed the following research questions:

How are different aspects of digital HLE related to ICT self-efficacy?

With regard to the former results on the influence of digital HLE on ICT self-efficacy (Aesaert & van Braak, 2014; Hatlevik et al., 2018; Vekiri, 2010a), we suggest the following:

H_1 All aspects of digital HLE (stimulation, instructions, interactions, and modeling) are positively related to children's ICT self-efficacy.

H_2 We expect the largest contribution to ICT self-efficacy to concern the modeling aspect and the smallest contribution to concern the stimulation aspect. The level of association between instructions and interactions will be between the stimulation and the modeling aspect.

Based on research on gender differences in ICT self-efficacy, particularly the findings of Vekiri and Chronaki (2008), as well as those of Rohatgi et al. (2016), the second research question addresses gender differences in the relationship between digital HLE and ICT self-efficacy:

Does gender moderate the relationship between digital HLE and ICT self-efficacy?

H_3 We expect that gender moderates the relationship between digital HLE and ICT self-efficacy. Because previous research on moderator effects showed heterogeneous results, we

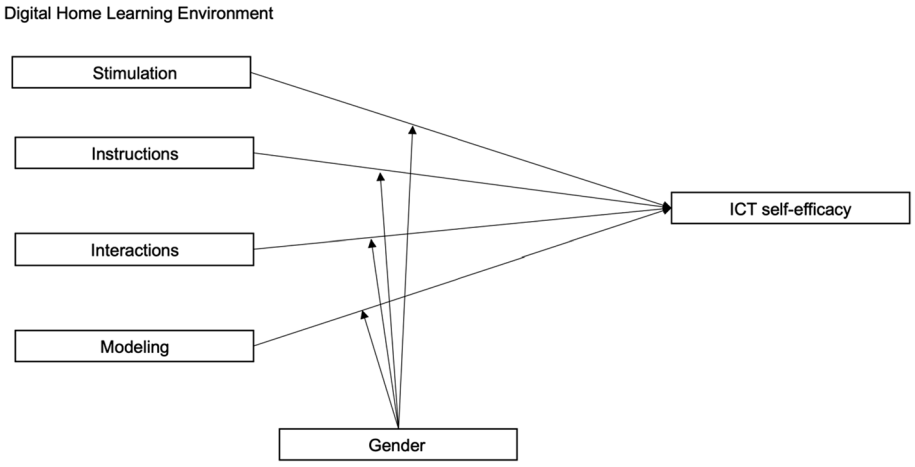

Fig. 1 Proposed research model

do not have a hypothesis regarding the direction of the moderator effect. An overview of our hypotheses is provided in *Fig. 1*.

Method

Procedure and participants

The study took place at five different secondary schools located in two medium-sized cities in the northwestern region of Germany. Contact was made via the school principals. After we obtained their consent for the study, every child, with the permission of his or her parents, answered a questionnaire in the classroom during regular school hours. A total of 651 fifth and sixth graders (324 girls) participated in the study. We chose grades 5 and 6 for two reasons. First, we expected that the parents of fifth and sixth graders would still have considerable influence on digital HLE activities. Second, we expected variance in ICT use and experiences at this age. In all, 25.2% of the students attended a regular secondary school (Realschule/Sekundarschule), 59.3% attended a secondary school qualifying for university admission (Gymnasium), and 15.4% were enrolled in a comprehensive school (Gesamtschule). In total, 31.49% of the children who participated in our study had at least one parent who was born in a country other than Germany. This proportion is only slightly lower than the total proportion of children (aged 10 to 15) with a migration background who live in Germany (34.1%; Statistisches Bundesamt [German Federal Statistical Office], 2016). The students' ages ranged from 10 to 14 years ($M = 11.21$, $SD = 0.75$). Nearly every student had access to the Internet at home (92.8%) or to a smartphone with an Internet connection (93.5%). Only 10 students who had accessed neither the Internet nor a smartphone participated in the study. These students were excluded from further analysis. Therefore, the final sample size was $N = 641$. Table 1 shows further sample information about the sample's access to digital media.

Significant gender differences in digital media access existed solely in children's individual computer/notebook access.

Table 1 Digital media access in total and by gender

Digital media access		Boys (%)	Girls (%)	χ^2 (1)	All (%)
Internet	Family	94.7	92.8	0.96	93.5
	Child	70.7	68.1	0.52	69.2
Smartphone	Family	93.2	93.0	0.01	93.1
	Child	90.5	86.5	2.34	88.1
Computer/notebook	Family	98.1	97.4	0.31	97.7
	Child	53.1	40.8	9.46**	54.2

**$p < .01$; $N = 651$

Instruments

Digital home learning environment (HLE)

Focusing on the four described aspects of HLE (stimulation, instructions, interactions, and modeling), digital HLE was assessed by six different indicators. Regarding the stimulation aspect, the child's *individual computer access* was assessed by one dichotomous variable (see Table 1; Vekiri & Chronaki, 2008), and *cultural capital* was measured by the number of books at home (one item coded: 1 refers to 0–10 books, 2 to 11–25 books, 3 to 26–100 books, 4 to 101–200 books, and 5 to over 200 books; Senkbeil & Ihme, 2017).

Regarding the instructions, Internet support was measured by the frequency of *parents' instructional Internet support* for schoolwork (4 items; response scale ranged from 1 = never to 5 = very often). We adapted this scale from the German PIRLS (Progress in International Reading Literacy Study), which assessed the frequency of different strategies of text comprehension (Bos & Lankes, 2005). The formulations were modified from the text comprehension context to the field of Internet inquiries.

The interaction aspect was measured using the *shared Internet activities* scale, which represented an informal part of parents' Internet support (4 items; response scale ranged from 1 = never to 5 = very often). The items measured joint Internet searches concerning the planning of school and free-time activities. The items were adapted from a German-based analysis of six- to 13-year-olds' media use (Medienpädagogischer Forschungsverbund Südwest [mpfs], 2016).

The modeling aspect of the digital HLE was measured according to two different kinds of parental attitudes toward the Internet: *positive attitudes* and *critical attitudes*. Both aspects were measured by 3 items. Children responded to a five-point Likert-type scale (1 = does not apply at all to 5 = applies absolutely). The two attitude scales were adapted from Gniewosz and Noack (2012).

ICT self-efficacy

Children's *ICT self-efficacy*, as the dependent variable, was measured by an adaptation of Schwarzer and Jerusalem's (1999) general self-efficacy scale. We assessed how children evaluate their ability to solve problems during Internet inquiries (5 items; response scale ranging from 1 = does not apply at all to 5 = applies absolutely).

Further information and the wording of all items, as well as internal consistencies, are presented in Table 2.

Statistical analyses

To test the hypotheses, confirmatory factor analysis (CFA) and structural equation modeling (SEM) were conducted using the software R (Version 3.3.2, R Core Team, 2016) with the package lavaan for the CFA and SEM (Rosseel, 2012) and semTools for the measurement invariance tests (Version 0.4–14; Jorgensen et al., 2016). The missing values for all variables ranged from 0.63 to 5.79% ($M = 2.08\%$) and were completely random; therefore, we used the full information likelihood method to impute the missing values (Graham, 2009). To determine whether the assumed model fit the data, the following goodness-of-fit indices and their cutoff criteria were used (Beauducel & Wittmann, 2005; Hu &

Table 2 Measurement instruments

Dimension	Items	Factor loadings λ	*M*	*SD*	α
Instructions					
Instructional Internet support	How often do your parents help you to search the Internet?				
	(1) My mother/father types words into a search engine for me	.60	1.84	0.81	.78
	(2) My mother/father observes me typing words into a search engine	.70			
	(3) My mother/father suggests words, which I can type into a search engine	.78			
	(4) My mother/father suggests homepages, which can help me to find proper information	.68			
Interactions					
Shared Internet activities	How often do you search the following things together with your parents on the Internet?				
	(1) Things I want to buy	.60	1.87	0.77	.63
	(2) Opportunities for free-time activities in the immediate vicinity	.73			
	(3) Handicraft tutorials	.44[1]			
Modeling					
Positive attitude	My parents think that …				
	(1) Internet competence is important to earn a significant amount of money in the future	.58	2.68	0.97	.75
	(2) Internet competence is important for later vocational training	.79			
	(3) Internet competence is important to find a good job in the future	.76			
Critical attitude[1]	My parents think that …				
	(1) working with the Internet is boring	.45[1]	2.49	0.91	.60
	(2) working with the Internet is a waste of time	1.02[1]			
	(3) being on the Internet is bad for school success	.33[1]			
ICT self-efficacy	(1) I could handle the surprising results of my Internet search	.76	3.35	0.86	.86
	(2) I look forward to solving problems during Internet searches because I can trust my skills	.76			
	(3) It does not matter what happens during an Internet search; I will handle it	.77			
	(4) If I get in contact with something unknown during an Internet search, I will know how to handle it	.76			
	(5) If I encounter a problem during an Internet search, I can handle it on my own	.67			

All factor loadings are significant $p < .01$.

[1]These items and scale have been excluded from further analyses because of small factor loadings and the Heywood case

Bentler, 1999): chi-square/df (≤ 2.0 excellent model fit), comparative fit index (CFI > 0.9 acceptable and > 0.95 good model fit), and the root mean square error of approximation (RMSEA < 0.05 excellent model fit).

To test the hypotheses concerning the moderation effect of gender, a multiple-group SEM was conducted, with gender as the grouping variable (Steenkamp & Baumgartner, 1998; Steinmetz et al., 2009). Measurement invariance is a prerequisite for testing moderation effect. Minimum levels of invariances are full configural invariance and at least partial metric invariance across groups. Therefore, several tests of measurement invariance were conducted before we constrained the regressions to be equal across groups (structural invariance). The model fit of the structural model was compared to the model fit of the (partial) metric invariance model using χ^2-tests (Evermann, 2010; Millsap, 2012). Due to χ^2 often being significant because of its sensitivity to sample size, further criteria of measurement invariance were consulted. When sample sizes are unequal, an acceptable change in CFI would be < 0.005 and in RMESA < 0.010, noting the change in CFI as the main criterion (Chen, 2007).

Results

Evaluation of the measurement and structural model

To test whether the items of all scales were selective, all scales were tested together in one measurement model using CFA. The results showed good model fit (χ^2 (125) = 182.256, $p < 0.001$, CFI = 0.978, RMSEA = 0.028, SRMR = 0.037). When the measurement model was evaluated, some problems emerged in measuring the *critical attitude* of parents toward Internet use. First, Items 1 (0.45) and 3 (0.33; see Table 2) had factor loadings under 0.5 (Hair et al., 2010). Second, we detected a Heywood case in Item 2, which means that the factor loading was greater than one (1.02) with a negative residual variance. Heywood cases can indicate model misspecifications (e.g., extracting too many factors; Rindskopf, 1984). Regarding these problems, we decided to exclude the *critical attitude* scale from further analysis. Furthermore, one item was excluded from the *shared* scale because of factor loading under 0.5 (Hair et al., 2010). Testing the measurement model with this adapted version also resulted in good model fit (χ^2 (71) = 108.723, $p < 0.01$, CFI = 0.984, RMSEA = 0.030, SRMR = 0.030).

The applied structural equation model showed a good model fit (χ^2 (91) = 149.139, $p < 0.001$; CFI = 0.976; RMSEA = 0.033, SRMR = 0.031). All covariances between the latent factors remained free.

Relationship between digital HLE and ICT self-efficacy

The first research question addressed the association between the five remaining indicators of digital HLE and ICT self-efficacy. All the digital HLE variables together explained 14% of the variance in ICT self-efficacy. Table 3 presents all associations between digital HLE and ICT self-efficacy. Except for children's individual computer access, all variables showed a significant effect on ICT self-efficacy. Table 3 shows that number of books, positive attitude, and shared Internet activities had a positive relationship with ICT self-efficacy, whereas parental instructions had a negative relationship. Consequently, if children perceived parental instructions during their ICT use more often, they reported a lower level

Table 3 Associations between digital HLE and ICT self-efficacy

Variable	Correlations				
	1	2	3	4	5
(1) Individual computer access[a]	–				
(2) Number of books[a]	.00	–			
(3) Instructions[a]	− .03	.03	–		
(4) Shared Internet activities[a]	.16**	.01	.31***	–	
(5) Positive attitude[a]	.13**	.00	.12*	.25***	–
(7) ICT self-efficacy[2]	.04	.14**	− .13**	.21***	.24***

[a]Correlation coefficients between constructs

[b]Regression coefficients of SEM. *$p < .05$. **$p < .01$. ***$p < .001$

of ICT self-efficacy. Thus, concerning Hypothesis 1, not all aspects of the digital HLE were related positively to ICT self-efficacy.

Regarding Hypothesis 2, we expected that the modeling aspect (positive attitude) of the digital HLE would show the largest regression coefficient and therefore the largest contribution to ICT self-efficacy, while the stimulation aspect (computer access and number of books) would show the smallest regression coefficient. We can conclude that parents' positive attitude toward the Internet showed the largest regression coefficient. With regard to the stimulation aspect, on the one hand, the children's individual computer access was not significantly related to their ICT self-efficacy. On the other hand, the number of books at home was significantly related to children's ICT self-efficacy. As expected, the regression coefficient was smaller compared with the regression coefficients for shared Internet activities and positive attitude. Compared with the regression coefficient for instructions, it was slightly larger. Furthermore, we assumed in Hypothesis 2 that the level of the regression coefficients for instructions and interactions would fall between the level of the regression coefficients for modeling and stimulation. The regression coefficient for instructions was smaller compared with the other independent variables. With regard to the interaction

Table 4 Associations between digital HLE and ICT self-efficacy separated by gender

Variable	Correlations				
	1	2	3	4	5
(1) Individual computer access[a]	–				
(2) Number of books[a]	− .06/.07	–			
(3) Instructions[a]	− .09/.08	.05/.00	–		
(4) Shared Internet activities[a]	.19**/.10	− .04/.06	.37***/.17	–	
(5) Positive attitude[a]	.16*/.05	.04/-.07	.14*/.10	.23**/.27	–
(6) ICT self-efficacy[b]	.02/.06	.16*/.10	–.08/–.20*	.28**/.15	.24**/.20*

[a]Correlation coefficients between constructs.

[b]Regression coefficients of SEM; The regression coefficients are shown for girls before and boys behind the slash.

* $p < .05$. ** $p < .01$. *** $p < .001$

Table 5 Measurement invariance

Type of invariance	Statistic							
	χ^2	*df*	CFI	ΔCFI	RMSEA	Δ RMSEA	AIC	BIC
Configural invariance	247.597	182	0.974		0.035		25,797	26,341
Metric invariance (loadings)	267.487*	192	0.970	0.004	0.036	0.001	25,800	26,300
Structural invariance (regressions)	272.078	197	0.970	0.000	0.036	0.000	25,795	26,272

*$p < .05$

aspect, we can maintain our hypothesis. The level of the regression coefficient for shared Internet activities and ICT self-efficacy was between the modeling and stimulation aspects.

Gender as a moderator

The second research question addressed the moderation effect of gender. The multiple-group model, which included gender as a group variable and assessed configural invariance, showed good model fit (see Table 5). It was not significantly worse than the model fit that did not include gender as a moderator (see first research question). The associations between the digital HLE and ICT self-efficacy, separated by gender, are presented in Table 4.

For girls, the digital HLE explained 18% of the variance in ICT self-efficacy and, for boys, it explained 11%. Descriptively, gender differences in regression coefficients can be observed in the relationship between ICT self-efficacy and number of books, positive attitude, shared Internet activities, and instructions. For girls, there were larger regression coefficients for number of books, positive attitude, and shared Internet activities than for boys. For boys, there was a significant negative association between instructions and ICT self-efficacy, whereas this association was not significant for girls.

To test whether the moderation effect of gender is significant, we applied different tests of measurement invariance and constrained regression effects to be equal across groups. Table 5 shows the fit indices for the different measurement invariance models.

Table 6 Standardized path coefficients, z-values from SEM, and hypotheses

Path	Standardized path coefficient	*z*-value	Hypotheses
Paths for girls and boys together			
Individual computer access ICT self-efficacy	0.04	0.942	Not supported
Number of books ICT self-efficacy	0.14	2.998**	(Partially) supported
Instructions ICT self-efficacy	− 0.13	− 2.399*	Not supported
Shared Internet activities ICT self-efficacy	0.21	3.207**	Supported
Positive attitude ICT self-efficacy	0.24	4.256***	Supported
Gender moderates the relationship between digital HLE and ICT self-efficacy	–	–	Not supported

*$p < .05$. **$p < .01$. ***$p < .001$

The test of metric invariance resulted in a significantly worse model fit, but the changes in CFI and RMSEA did not cross the cutoff criteria (see Table 5). The next step was to compare the metric invariance model with the structural invariance model. In the structural invariance model, the effects of the digital HLE were constrained to be equal across groups. The comparison to the metric invariance model did not show worse model fit. This means that Hypothesis 3, which argues that gender moderates the relationship between the digital HLE and ICT self-efficacy, must be rejected: The regression coefficients for the digital HLE and ICT self-efficacy did not differ significantly across genders. Table 6 summarizes all hypotheses regarding the contribution of the digital HLE to ICT self-efficacy and illustrates whether our hypotheses were supported or not.

Discussion

This study sheds light on an important part of research on learning environments by examining the contribution of a variety of variables of the digital HLE to ICT self-efficacy. Our study focused on self-efficacy and HLE in the digital age, and the results expand on former findings of learning environments research, which has a long tradition of investigating classroom environments (Fraser, 2019; Zandvliet, 2019). The integration of new technologies into schools will make a clear distinction between formal and informal learning contexts more difficult; our study provides insights into different aspects of informal learning. Using the HLE framework (Bradley & Corwyn, 2005), it was possible to integrate well-established concepts of ICT research, such as parental strategies of active co-use or computer access, into a broader theoretical model. Furthermore, we were able to emphasize new dimensions, such as parent–child interactions with ICT, parental instructions during their children's ICT use, and parents' attitudes toward the Internet. In particular, the comparison of different digital HLE aspects provides a better understanding of the development of motivational beliefs, such as ICT self-efficacy (Hatlevik et al., 2018).

The first research question addressed associations between these different qualities of the digital HLE and ICT self-efficacy. Significant associations emerged between three digital HLE dimensions: stimulation (number of books at home and computer access), interactions (shared Internet activities), and modeling (parents' positive attitudes toward the Internet). Effect sizes in our study are comparable to those in former ICT research on family factors (Aesaert & van Braak, 2014; Hatlevik et al., 2018). Our hypothesis regarding the contribution of the stimulation aspect of digital HLE to ICT self-efficacy was only partially supported. Stimulation, which means that parents create opportunities for their children's exploration and learning, was operationalized by children's individual computer access and the number of books at home. Whereas the results regarding the number of books supported our hypothesis, individual computer access, which can be assumed to be more related to the ICT context, did not show a significant contribution to ICT self-efficacy. One possible explanation is that ICT self-efficacy does not depend on computer access itself because how children use ICT is more important (e.g., programs, frequency of use, and type of ICT used at home; Gruchel et al. 2021). For example, research on gender differences revealed that the type of ICT use is crucial (Lorenz et al., 2014; Tsai & Tsai, 2010; Vekiri, 2010b). Another possible explanation is that the contribution of computer access is mediated by the other digital HLE indicators. In that case, it will serve as a prerequisite for more interactive aspects of digital HLE, such as instructions and parent–child ICT activities (Gruchel et al., 2021; Wieschollek et al., 2018).

In this study, we found an unexpected significant negative association between parents' instructions and help during children's Internet activities and ICT self-efficacy. One possible interpretation is that children with lower ICT self-efficacy ask for more help during their Internet work because they do not trust their own abilities. Another possible explanation is that, because of frequent interruptions by parents during their children's Internet tasks, children are unable to develop a positive ICT self-efficacy and, rather, develop low self-efficacy regarding their Internet work. Research concerning parental involvement in homework has shown similar results. For instance, Dumont et al. (2014) found a reciprocal relationship between children's reading achievement, homework behavior, and parents' control strategies during children's homework. They reported a small negative effect of parents' control strategies on children's reading achievement at the first measurement point. Furthermore, parents' control strategies resulted in children's higher homework procrastination at a second measurement point. While talking about control strategies, we need to consider that actual definitions of parents' controlling behavior comprise rather negative forms of parenting (Grolnick & Pomerantz, 2009). It is possible that the children in our study also interpreted the instruction scale items negatively. To summarize the results of the first research question, our study supports the importance of digital HLE in the development of ICT self-efficacy.

To address the second research question, we investigated whether the associations between digital HLE and ICT self-efficacy differ across genders. Descriptively, we saw gender differences in the relationship between ICT self-efficacy and number of books, positive attitude, shared Internet activities, and instructions. Except for the association with instructions, the impact of the relationships with ICT self-efficacy were greater among girls. Rohatgi et al. (2016), who observed slightly-different types of ICT use at home and their relationship to ICT self-efficacy, found similar results. Associations between a general measure of ICT use at home and ICT self-efficacy were stronger for girls than for boys. In contrast to our findings, Vekiri and Chronaki (2008) reported slightly-stronger effects of parental support on computer self-efficacy for boys than for girls. In contrast to the previous studies, we tested the significance of these moderation effects. Because the results showed that our moderation effects were not significant, we limited the interpretation of gender differences. It is important to investigate moderation effects more systematically. Further research is needed to describe more precisely the ways in which girls and boys develop in their digital HLE, because these differences might be reproduced in other learning environments, such as schools or peers. Teachers in particular could benefit from such knowledge.

With respect to the HLE framework, we focused on only four of five possible major aspects of HLE. The motivational aspect of HLE was neglected in our study. Future research should consider this aspect by addressing research questions such as the following: How motivating and encouraging are parental instructions during Internet searches and parent–child ICT activities? Using self-determination theory (Ryan & Deci, 2000), Dumont et al. (2014) examined parental homework involvement and showed that autonomy supportive, responsive, and well-structured support positively influenced children's motivation. Additionally, in other domains, such as reading literacy or numeracy, there are different approaches to distinguishing between the various facets of the HLE. For example, there are differentiations between informal and formal HLE (Niklas et al., 2016) and passive and active HLE (Wieschollek et al., 2018). Future research should consider these different approaches. Owing to small factor loadings and the Heywood case, one item of the *shared Internet activities* scale and the whole *critical attitude* scale were excluded from further analyses. In studies regarding the general attitudes of parents toward education,

critical attitude seemed to be a reliable measure (Gniewosz & Noack, 2012). Börner (2016) showed that, if parents have critical attitudes toward ICT, they were more uncertain regarding ICT use in general. Furthermore, parents who were more concerned about Internet risks applied more parental mediation strategies. For future research, the fit of the items of the critical attitudes scale to ICT contexts should be revised and inspected more carefully. For more information on the validity of the measurements, further longitudinal data are necessary.

This study's cross-sectional design leads to some limitations regarding the interpretation of the associations. Using a long-term perspective in further research could generate more evidence for the development of differences and causal effects in ICT self-efficacy. Furthermore, we focused solely on children's perceptions of digital HLE in this study. To expand learning environments research, it is relevant to combine parents' and children's perceptions. It might also be interesting to compare the influence of the different qualities of digital HLE, which we investigated in this study, to other sources of self-efficacy, such as peer-group or school experiences (Aesaert & van Braak, 2014). Our sample represents a good distribution of school tracks from which German students can choose for their education after primary school. Furthermore, the proportion of students with migrant backgrounds in our sample is very similar to the proportion of students with migrant backgrounds in the whole German population. Nevertheless, we need to limit the interpretation of our results with regard to generalization. It might be possible that, in studies with older children, the model of the different qualities of digital HLE cannot be replicated because the views on HLE might change over time (Senkbeil & Ihme, 2017). Owing to small factor loadings, some items of the scales were excluded from further analyses. For more information on the validity of the measurements, further longitudinal data are necessary. Additionally, because ICT access and use still differ between countries (Bundsgaard & Gerick, 2017), further research is needed into the perception of the digital HLE and its relationship to ICT self-efficacy over time and between countries (Aesaert & van Braak, 2014; Hatlevik et al., 2018).

Conclusion

Self-efficacy is an important precursor of digital literacy, and both are essential for students to receive a high-quality and gratifying education and to succeed in school. The present study filled an important gap within the field of learning environments research by examining the contribution of a variety of HLE variables to ICT self-efficacy. In particular, parents' positive attitudes and parent–child Internet activities, such as searching the Internet for information to plan weekend activities, contributed positively to ICT self-efficacy. This knowledge can be used by educators to support families with questions regarding the use of ICT at home. Teachers' guidance can help parents to find the right balance between restrictive parental mediation strategies and the provision of interactive informal learning opportunities which, in turn, have positive consequences for the child's learning (Livingstone et al., 2017). Furthermore, parents' prejudices regarding ICT use at home could be elucidated. Clarification regarding ICT use at home is needed to suggest to parents how they can interact productively with their children using ICT. The benefits and risks of children's ICT use at home must be discussed to create a positive and autonomous learning environment, avoiding instructions and control strategies during children's ICT use, while establishing supportive surroundings. Furthermore, the results of the present study can help educators

who want to use ICT to integrate informal learning strategies into formal learning settings (Kumpulainen et al., 2018; Lewin & Charania, 2018). Research supports that students can adapt more easily to using digital tools for recreational purposes than for school success (Eastin & LaRose, 2000; Hatlevik et al., 2018; Rohatgi et al., 2016). For example, if a student feels self-confident regarding recreational ICT use, teachers can foster this self-confidence by using similar programs and tools in schools. Therefore, learners who are not usually engaged could become engaged through the establishment of a stronger connection between out-of-school settings and school. It is also important to note certain attributes of informal learning in family contexts because many authors have difficulty formulating a distinct definition of formal and informal learning (Lewin & Charania, 2018). Coincidentally, prominent attributes of informal learning refer to learning that is strongly linked to everyday life. Informal learning is also framed by the relationship between children and their parents outside formal education (Bonanati et al., 2020), which is described as "concrete, interest and practice-driven" (Lewin & Charania, 2018, p. 201). It is important to reflect on how these attributes can be adapted to ICT use in schools and how ICT use in schools bridges the gap between formal and informal learning. In summary, our results underline the importance of attitudes toward new technologies and different kinds of interactive ICT practices. It should be taken into account that not all kinds of instructions and support have a positive impact on motivational beliefs.

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