



MASTERTHESIS

*Exploring effects of the
digital home literacy
environment on early
literacy and vocabulary
skills of first graders*

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After two academic years at the University of Twente, I am proud to finish my student life with the master Educational Science and Technology. Writing a master thesis on effects of digitality on the development of language and literacy was very exciting for me with a background as a speech and language therapist. However, I could not have imagined beforehand that the possible influencing digital factors on this subject, would become more accurate than ever with the advent of COVID-19 pandemic.

Writing this thesis was a tough, but also challenging period. Nevertheless, I am proud of what I have overcome and of what I have learned during this period in terms of new insights and skills in the broad field of educational science. I could not have done this without the cooperation and support of a number of people in particular. First of all, I would like to thank my first supervisor, dr. J. (Judith) ter Vrugte and my second supervisor Prof. Dr. P.C.J. (Eliane) Segers. Thanks to their accessibility, patience, motivational speeches and straight forward feedback, I was able to overcome the challenges of the thesis, which led me to this result. Next, I would also like to thank my project partner with whom I collected all the data and spent many hours sparring. At last, I would like to thank my partner and closest family and friends for the mental support I needed during this period.

Thank you!

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Abstract

This study investigated how aspects of the digital home literacy environment (DHLE) relate to the early literacy and vocabulary skills of first graders. More specifically, it was investigated whether the digital counterparts of known analogue predictors for literacy in the home environment (i.e., the home literacy environment), had similar predictive values for children's literacy and vocabulary skills in the first grade. The parents of 53 kindergarteners were interviewed about their DHLE (i.e., materials, device use, literacy activities, parental characteristics). In addition, in the first semester of first Grade, their children were assessed for vocabulary skills and early literacy skills (phoneme-grapheme knowledge and phonological awareness). The results showed that formal device use was not a predictor for both skills. Parents' modelling behaviour in the area of performing digital educational literacy activities, and the children's performance of digital leisure literacy activities, were found as predictors for vocabulary skills. No predictors for early literacy skills could be found. Despite parents awareness of the potential of digital resources for literacy learning, it was minimally implemented in the HLE. It can be concluded that the DHLE has not replaced the analogue HLE yet, but is so far only complementary. More attention is needed to this part of the home environment, where children grow up with many literacy stimulating possibilities, right at their fingertips.

Deze studie onderzocht hoe de aspecten van de digitale geletterde thuisomgeving (DHLE) samenhangen met de beginnende geletterdheid en woordenschatvaardigheden van kinderen uit groep 3. Er werd hierbij specifiek gekeken of de digitale tegenhangers van bekende analoge voorspellers voor geletterdheid in de thuisomgeving (d.w.z. de digitale geletterde thuisomgeving), vergelijkbare voorspellende waarden bezaten voor de geletterdheid en woordenschat van kinderen uit groep 3. De ouders van 53 kleuters werden geïnterviewd over hun DHLE (d.w.z. materialen, apparaat-gebruik, taal- en geletterdheid activiteiten, en de ouderlijke kenmerken). Daarnaast werden in het eerste semester van groep 3, hun kinderen getoetst op hun woordenschat en beginnende geletterdheid (foneem-grafeem kennis en fonologisch bewustzijn). De resultaten toonden dat formeel apparaat gebruik geen voorspeller was voor beide vaardigheden. Modelleringsgedrag van ouders op het gebied van het uitvoeren van digitale educatieve geletterdheidsactiviteiten, en het uitvoeren van digitale vrijetijd geletterde activiteiten door de kinderen, bleken daarentegen wel voorspellers te zijn voor woordenschat. Voor beginnende geletterdheid konden er geen voorspellende waarden worden gevonden. Ondanks dat ouders weliswaar het potentieel van digitale middelen voor het stimuleren van geletterdheid zagen, werd dit minimaal geïmplementeerd in de geletterde thuisomgeving. Geconcludeerd kan worden dat de DHLE de analoge geletterde thuisomgeving niet heeft vervangen, maar tot nu toe slechts complementair is. Meer aandacht is nodig voor dit deel van de thuisomgeving, waarbij talrijke digitale taal- en geletterdheid stimulerende mogelijkheden letterlijk onder de vingertoppen van kinderen beschikbaar zijn.

Keywords: digital home literacy environment, early literacy skills, vocabulary skills, digital literacy activities, parental characteristics

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Introduction

The Inspectorate of Education reports that more than a quarter of Dutch pupils leave primary school with literacy skills below the fundamental level (Inspectie van Onderwijs, 2021). This is problematic, as well-developed literacy skills, like well-developed language skills, are essential; They are considered as a basic requirement for participation in society and a prerequisite for independence and self-reliance (Stichting Lezen en Schrijven, 2021). Both skills, when underdeveloped, have a negative impact on later academic functioning (Milton & Treffers-Daller, 2013). Moreover, researchers agree that children's early development of language and literacy skills (i.e., kindergarten years and before) play an essential role in children's successful development of language and literacy skills later in life (Biemiller, 2016; Lee, 2011). Because development takes place in the early years, the home environment plays an important role in the development of these early literacy and language skills (Mol & Bus, 2011; Sénéchal et al., 1998).

Specific aspects in the home environment have proven to impact early literacy and language development (e.g., Mol & Bus 2011; Martini & Sénéchal, 2012; Sénéchal & LeFevre, 1998). Taken together, researchers commonly refer to these aspects as the *home literacy environment*. In general, studies of the home literacy environment include aspects related to the amount of available language and literacy stimulating materials, the frequency and quality of activities that promote early literacy and language development, and parental factors such as parental attitudes and expectations of literacy and language learning (e.g., Martini & Sénéchal, 2012; Nag et al., 2019; Sénéchal & LeFevre 2002). Over the years scientists have attempted to create models that show the relation between these aspects and the development of early literacy and vocabulary skills. However, recent technological developments may have impacted previously established relationships.

Technology has taken a prominent role in contemporary households and progressively replaces or adapts traditional aspects of the home literacy environment. For example, traditional printed materials (e.g., newspapers, books, and magazines) increasingly make way for digital variants which often include multimedia. Researchers refer to these digital variants of aspects of the home literacy environment as the *digital home literacy environment* (e.g., Lehlr et al., 2021; Neumann, 2016; Radesky et al., 2015; Silinskas et al., 2020). Despite its unique affordances and plausible impact on traditional models, research addressing the digital home literacy environment is scarce. Examining the digital home literacy environment, would not only advance our understanding of the modern home literacy environment and its impact on literacy and vocabulary development, it might also provide insight into how technology can best be used in the home environment to complement or improve the quality of (analogue) literacy activities and thus improve the learning outcomes of young children (Neumann & Neumann, 2014). Therefore, this study explored to what extent previously established relations of the home literacy environment also apply to the digital variant of the home literacy environment.

Early literacy and vocabulary skills development

Early literacy can be defined as the early phase of written language acquisition, which starts from the child's birth and ends when the child is proficient in basic reading and spelling. Sénéchal (2006) counts phonological awareness, letter naming knowledge, phoneme-grapheme knowledge and reading with help, as part of early literacy. Early literacy skills, as well as the young child's vocabulary skills, have been shown to be crucial to children's later reading and spelling skills. For example, early literacy and vocabulary skills at a young age have been shown to have predictive value to word reading and spelling skills in Grade 1, and on reading comprehension, reading fluency, and spelling skills in Grade 4 (e.g., Brock & Rankin, 2008; Bowman & Treiman, 2008; Sénéchal, 2006). And the home environment that a child grows up in, has a decisive role in the development of these early literacy and vocabulary skills (e.g., Bus et al., 1995; Melhuish et al., 2008; Mol & Bus, 2011).

Home literacy environment

Material in the home environment

One of the aspects at home that contributes to the quality of the home literacy environment (HLE) is the amount of books or other printed material in the child's home and the access to these materials (Burgess et al., 2002; Nag et al., 2019). For example, Nag et al. (2019) showed with their review that the numbers of books in the home environment predicted difference in language tests. These effects were found across different grades, languages and orthographies. Segers and Kleemans (2020) also recently found an association between the number of books in the home environment and language proficiency, but could not find such an association for early literacy skills. Literacy material in the home environment has been found to be a predictor of literacy at a later age, from fourth grade onwards, specifically for reading comprehension and reading comprehension (Bergen et al., 2017; Park, 2008). More important than availability of printed material in the child's home environment, or the access to these materials, is their use. The greatest impact of these materials on literacy development is achieved when they are used frequently and qualitatively by the children (e.g., Park, 2008; Leseman & de Jong, 1998; Sénéchal & LeFevre, 2002).

Literacy activities

Books or other literacy stimulating materials are only partially accessible to young children and need parental guidance to lead to literacy activities (Bus et al., 1995). With literacy activities we refer to an accumulation of activities at home that include literacy stimulation. These activities are largely responsible for the variation in the development of language and early literacy skills (Park, 2008; Sénéchal, 2006). According to Sénéchal and colleagues (2002), literacy activities can be divided into formal and informal activities. Formal activities are literacy activities *with the aim of teaching a child*, such as teaching the name graphemes of the child's name (Smolkin & Yalden, 1992). While informal literacy activities do not have this intention. They have the pure purpose of entertaining a

child, like reading bed-time stories. It should be noted that, based on its face value, it is often difficult to assess the informal or formal nature of an activity, because it is about *the intention* with which an activity is carried out. For example, reading a story to a child can be done both formally and informally.

Sénéchal and LeFevre (1998) found a differential effect of formal and informal literacy activities on children's early literacy and vocabulary skills. Formal home literacy activities, also known as 'parent teaching' or 'home tutoring', had a positive relationship with early literacy skills (Sénéchal et al., 1998; Silinskas et al., 2020). Informal literacy activities were found to have a positive relationship with the child's vocabulary skills (Sénéchal et al., 1998). Sénéchal and LeFevre (2002) found that these effects of the formal and informal literacy activities were also lasting in the long term: the effects were demonstrable until at least children's reading performance in Grade 3. Sénéchal and LeFevre (2002) also found that vocabulary skills and early literacy skills had an effect on each other, but also both had an effect on phonological awareness. This effect on phonological awareness had in turn an effect on the development of reading skills, such as word-reading in the end of Grade 1, or the reading comprehension and reading fluency in Grade 4.

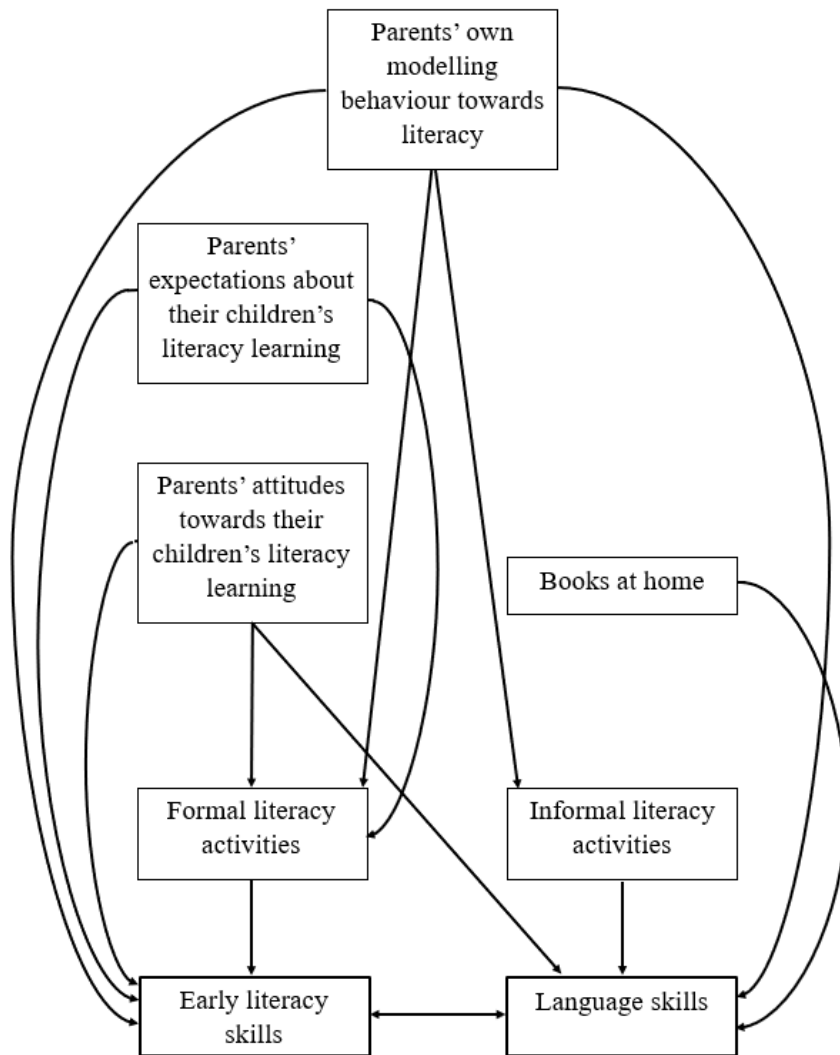
Parental characteristics

Other influential aspects of the HLE comprise parental characteristics (e.g., modelling behaviour, attitudes towards and expectations of their children's literacy learning). Nag et al. (2019) found in their review that parents' emotional response to reading and their own reading practice (collectively referred to as 'modelling behavior') showed a significant relationship with their children's language and early literacy skills. It was concluded that children are being influenced when they see the use of printed materials in their daily lives and associate this as positive, which impacts the children's practice of literacy activities.

Studies also showed a significant relationship between parents' attitudes and beliefs towards their children's literacy learning and their children's early literacy skills (Nag et al., 2019; Swain & Cara, 2017). More specific, studies showed that parents' attitudes towards their children's literacy learning and parents' expectations about their children's literacy learning had a direct as well as an indirect effect on early literacy, *via* the performance of formal literacy activities (Martini & Sénéchal, 2012; Silinskas et al., 2020). Thus, the frequency of literacy activities is partly the result of the parents' attitudes towards their children's literacy learning and parents' expectations about the child's school performance and abilities (Silinskas et al., 2020). For example, parents who had high expectations of their child in terms of literacy learning, participated also a lot in formal literacy activities when their child was still in kindergarten (Silinskas et al., 2020). All these findings for the analogue HLE are compactly presented in Figure 1.

Figure 1

The relationships within the analogue HLE model.



Note. This figure demonstrates the found relationships for the analogue HLE (e.g., Martini & Sénéchal, 2012; Nag et al., 2019; Silinskas et al., 2020; Sénéchal & LeFevre, 2002).

Digital home literacy environment

The HLE has expanded since 2010 with the advent of tablet computers and smartphones (Plowman & McPake, 2013). These and other technological devices are an integral part of modern Western households and are used by children in every level of society on a daily basis (Chaudron et al., 2015). Depending on the sufficient availability of devices and parents' attitude towards technology, young children have almost continuous access to digital devices. These digital devices are used frequently from an early age on, as evidenced by the fact that Dutch toddlers have an average of 98 minutes screen time per day (Netwerk Mediawijsheid, 2020). For these digital devices, there are an increasing number of apps that allow young children to engage in a lot of different literacy enhancing activities independent from their parents' supervision or guidance (Cohen, 2011).

It is likely that this digitalisation of the home environment and the educational opportunities it offers, will bring about shifts in the analogue model of the HLE. Therefore, researchers suggested to revisit and expand the HLE to include the digital advancements. Consequently, the *digital home literacy environment* (DHLE) was born (e.g., Lehl et al., 2021; Neumann, 2016; Radesky et al., 2015; Segers & Kleemans, 2020; Silinskas et al., 2020). Comparable to the established analogue HLE, the DHLE can be described as the shared digital literacy activities that children perform together with their parents, but also the digital literacy activities that children perform independently (Segers and Kleemans, 2020). In addition, the frequency with which a digital device is used to perform these digital literacy activities is also part of the DHLE (Lehl et al., 2021).

A limited body of research addresses the DHLE (e.g. Neumann, 2016; Radesky et al., 2015; Segers & Kleemans, 2020; Silinskas et al., 2020), but thus far it remains unclear which aspects of the analogue HLE are retained and how digital means influence these analogue means. Starting from the existing analogue HLE model (as shown in Figure 1) and the known effects and educational possibilities of technology, we will reason about this in the following paragraphs.

Material in the home environment

In contrast to the analogue HLE, where the number of books and other printed material is an influential factor, it is plausible that in the DHLE the amount of digital material is a weaker predictor of literacy and vocabulary skills or maybe even no longer significant. For example, Segers and Kleemans (2020) could not find an association between the number of devices at home with literacy skills of first graders. A plausible reason for the absence of this predictor in the DHLE is the fact that the number of books in the analogue HLE is strongly related to family's SES (Pace et al., 2017). As a result, many studies treat the number of books in the household as a proxy variable for family's SES (e.g. Bradley et al., 2001; Buchmann, 2002; Pace et al., 2017). However, nowadays every household, regardless of family's SES, has one or more digital devices at its disposal. This means that all children, have access to an infinite number of books or equal literacy material (Arends-Toth, 2019). This has basically equalised access to digital literacy material for every child, regardless of their family's SES.

This makes it theoretically plausible that it is not the quantity of material that is important for the development of literacy, but rather the literacy activities that are performed with this material.

Literacy activities

In contrast to the analogue HLE, in the DHLE there are numerous opportunities to practice digital literacy activities at all times with the numerous digital materials available. This digital material, compared to the analogue material, has unique multimedia features and possibilities for the stimulation of literacy development. For example, digital devices are easy for children to use, giving them easy access to literacy materials with built-in interactivity, which improves the quality of literacy activities (Chen, 2012; Mol et al., 2008). Another advantage of carrying out literacy activities digitally, is that literacy apps are programmed in such a way that a child can perform literacy activities independently. Whereas in the analogue HLE a child is mostly dependent on their parent's time or their sufficiency in literacy, the DHLE is omnipresent in which the child can carry out a literacy activity, both independently and under supervision.

Moreover, the children's unaccompanied, independent literacy activities are not inferior to parent-led literacy activities in terms of effectiveness (Neumann, 2016). The formal use of this digital material, seems promising for, for example, children growing up in low quality analogue HLE or a language-poor environment. It is plausible that the DHLE can improve here the quality or quantity of literacy stimulation, which will improve the degree of effectiveness on literacy development (Rowe, 2013). The scarce research that has been conducted for the DHLE has not yet zoomed in on this formal use of the new digital material in the home environment and its effect on literacy. This focus is interesting precisely to see to what extent digitality can change the influence of intention on the effectiveness of a literacy activity. Digitally performed literacy activities contain the same type of tasks regardless the intention, in contrast to analogue literacy activities, where the kind of execution is dependant of the intention of the supervising parent. For example, children can practise phonological skills through digital literacy activities in a playful way, without necessarily having the intention of learning anything. While such analogous exercises are not performed in the same way when the parent does not have the intention to teach the child anything.

Although it is difficult to ascertain the intention of a literacy activity, research has tentatively shown that performing literacy activities with digital materials is promising for the stimulation of children's literacy skills. For example, studies showed that technology-enhanced storytelling supported by a story structure and visual, auditory and textual prompts on a tablet computer had a positive effect on the vocabulary 2- to 5-years old children (Herodotou, 2018; Teepe et al., 2017). In addition, Neumann (2016) showed, as a pioneer in the field of DHLE, that children from 2 to 4 years of age who used the tablet computer a lot to practice their writing skills, had greater print awareness, print knowledge, and sound knowledge. Elimlech and Aram (2020) showed that practising writing and reading digitally via a computerised game on a device without parental guidance was effective for

early literacy skills, and also Lehl et al. (2021) showed recently positive effects of the digital performance of literacy activities on early literacy skills. However, the research results on digitally performed literacy activities are not unambiguous, as Segers and Kleemans (2020) were recent unable to demonstrate any relationship between digitally performed literacy activities on early literacy or vocabulary skills.

Parental characteristics

The earlier mentioned parental factors for the analogue HLE, can possibly also apply for the DHLE. However, these parental characteristics have hardly been studied for the DHLE. For example, there is still a lack of knowledge about the possible relation of the parents' own modelling behaviour towards literacy and their children's early literacy and vocabulary skills. Whereas in the analogue HLE parents' own modelling behaviour towards literacy sets an example which influences the child's behaviour regarding the use of literacy material, seems this relationship for the DHLE less plausible, because the device masks the activity; though a child will see the parent using a device, it will not see whether this is for leisure or for formal purposes. For example, a child sees a parent using a tablet, but can't see whether the parent reads a book, browses a website, or watches Netflix. In comparison, analogue activities are less opaque.

Also for the earlier factor from the analogue HLE, parents' attitudes towards their children's literacy learning, it is so far only known that parents who are positive about the use of devices are more inclined to undertake digital activities with their children than parents who are negative about it (Vandewater et al., 2005). For the third possible parental factor, parents' expectations about their children's literacy learning, Segers and Kleemans (2020) showed that there was still direct relationship with children's literacy learning, still had an effect on early literacy and vocabulary skills, but could not show any effect *via* the DHLE. This finding was mentioned as remarkable by Segers and Kleemans (2020), as they noted that parents with higher expectations can be seen as the early adapters who create a more comprehensive digital home literacy environment for their children. In addition, the so-called "Rosenthaler effect" can have caused here a direct relationship. This means that having high (parental) expectations, especially for first graders, causes children to develop and learn more quickly (Rosenthal & Jacobsen, 1968).

The present study

With the arrival of the digital addition to the HLE, the known relations between various aspects of the home literacy environment on early literacy and language skills might have changed. Whereas previously, for example, only the number of analogue books in the household mattered, it is now by comparison possible to easily have access to hundreds of e-books. This makes that this quantity of books no longer is a significant predictor of children's literacy development. However, the use of (digital) literacy material in the home environment and factors impacting this use might have become more relevant. Only recently, studies have carefully explored the role of digital media in models of home literacy: where previously, for example, only the analogue way of self-writing activities were questioned, the use of digital devices for the same purpose is now also questioned (Neumann, 2016; Segers and Kleemans, 2020). Despite its unique affordances, great potential and plausible impact on traditional models, research addressing the digital home literacy environment is scarce to date. Therefore, this study explores to what extent previously established relations of the home literacy environment to literacy and vocabulary development also apply to the digital variant of the home literacy environment, and how the home literacy environment model may have changed. More specifically, the following research question will be explored:

“To what extent do the different aspects of the digital home literacy environment predict the early literacy and vocabulary skills of first-graders?”

Based on previously established analogue models by Sénéchal and LeFevre (1998; 2002) Martini and Sénéchal (2012), Silinskas et al., (2020) and Nag et al., (2019) and on the scarce known effects of the DHLE (e.g., Elimlelech & Aram, 2020; Lehrl et al. 2021; Neumann, 2016; Segers & Kleemans, 2020), the following aspects of the digital home literacy environment are expected to predict children's literacy and vocabulary skills at the start of first grade, while taking into account previously established influential aspects like parents' expectations about their children's literacy learning, parents' attitudes towards their children's literacy learning and parents' own modelling behaviour towards literacy:

- The frequency of children's formal use of digital literacy material, the devices, for performing literacy activities
- The frequency of children's digital performance of literacy activities

In addition, some indirect relations are expected. First, based on findings for the analogue HLE (e.g., Martini and Sénéchal, 2012; Nag et al., 2019; Silinskas et al., (2020), it is hypothesized that the expected relationship between parents' expectations of their children's literacy and early literacy and vocabulary skills is mediated *via* formal use of digital literacy material.

Next, it is hypothesized that the expected relationship between parents' attitudes towards their children's literacy learning and children's early literacy and vocabulary skills, is mediated *via* formal use of digital literacy material. This expectation is based on the findings for the analogue HLE (Nag et al., 2019) and the fact that parents who are positive towards digital devices as a learning tool are more likely to support or assist their children in performing the digital literacy activities (Vandewater et al., 2005).

Lastly, contrary to the analogue HLE, no indirect relationship between parents' own modelling behaviour towards literacy and literacy skills is expected. Though for the analogue HLE researchers argue that the type of use by parents of analogue printed material will provide an example that a child will follow (Nag et al., 2019). We carefully conjecture that this will no longer hold true in the DHLE because the device masks the activity that a parent carries out on a device.

Method

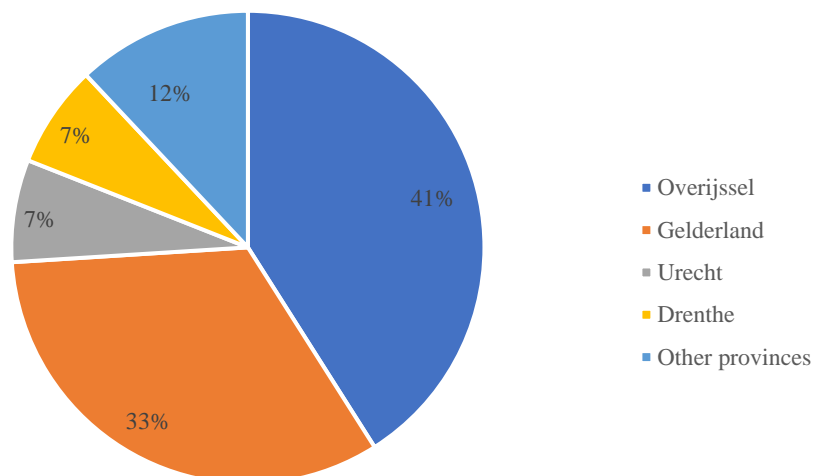
Research design and participants

This study followed a cross-sectional study design and employed mixed-method of quantitative and qualitative data. Data was collected by means of one interview with the primary caregiver and one measurement with the children. In total, 53 Dutch children and their parents participated. All children were in the second grade of kindergarten in the school year of 2019/2020. The sample consisted of 37 girls and 16 boys from 31 different schools from eight, mainly north and middle-east provinces of the Netherlands. All children of the sample were born between November 2013 and February 2015 and were on average 6 years and one month old at the time of the interview ($SD = 4$ months). At the time of the measurement, the average age of the participants was 6 years and 4 months ($SD = 4$ months).

Figure 3

Origin of participants per Dutch province

Participants per Dutch province



The participants who identified as the primary caregiver, were 3 fathers and 50 mothers. Concerning family composition, in 49 of the 53 households, the child was raised by both the father and the mother. In the remaining households children were raised by a single parent ($n = 2$), or co-raised by a parent and a stepfather or stepmother ($n = 2$). Three parents indicated that the spoken language at home was not Dutch. One of these three parents indicated that the language spoken at school never corresponds to the language spoken in the home environment.

Representativeness of the sample

This study started with 53 participants. Five parents and their children withdrew from the study before the second measurement moment. As a result, only 48 children completed the second measurement. The vast majority of the 91 parents of the 48 children, (aged 30 to 46 years) were relatively highly educated when compared to the Dutch population of the same age, as shown in Table 1 (CBS, 2021).

Table 1

Education level of the participation group versus education level of Dutch population

Highest education level achieved	Participation group		Dutch population*	
	Percent	Cumulative percent	Percent	Cumulative percent
Secondary school education or lower	5,50	5,50	18,43*	18,43
Secondary vocational education	26,37	31,87	28,69*	47,12
Higher vocational education or higher	68,13	100	52,88*	100
Total	100	100	100	100

*Adapted from “Bevolking, onderwijsniveau, geslacht, leeftijd en migratieachtergrond”, by Central Bureau of Statistics, 2021.

In the participant group, every household was found to have at least one digital device. More specific, 100% of the households had at least one smartphone, 97.91% had at least one laptop and 93.75% had at least one tablet. This is more than the amount of devices an average Dutch household held in 2019. For example, in 2019, 89% of the Dutch households had at least one smartphone, 79% had at least one computer and 66% had at least one tablet (Arends-Toth, 2019). Table 2 presents the average presence per device in the sample population as measured Likert scale ranging from 1 to 4 (i.e., 0 / 1 / 2 / >2).

Table 2

Average number of devices in a household (N = 48)

Device	M	SD	Minimum	Maximum
Number of televisions	2,52	0,71	1	4
Number of computers	3,10	0,93	1	4
Number of tablet computers	2,90	0,93	1	4
Number of e-readers	1,42	0,68	1	3
Number of smartphones	3,33	0,66	2	4
Number of audio devices	2,44	1,01	1	4
Number of game computers	1,69	0,83	1	4
Number of videoplayers	1,54	0,65	1	3

Interview

Information about the HLE of the children was collected via a structured response interview. The interview questions were based on the questionnaires of Segers, Kleemans, and Verhoeven (2015) and Segers and Kleemans (2020). In contrast to these questionnaires, the questions in this study were conducted in an interview, where the parents were asked questions and where the interviewer quantified the answers on a 4- or 5-point Likert scale. As the focus of this study was to identify the variation in the DHLE, questions were added to provide more insight into this variation. The interview consisted of four parts in which four different subjects were questioned, namely general demographic characteristics of the parent and the child, the available materials in the home environment, the use of digital devices and the parental characteristics.

The first part of the interview included questions about demographic characteristics of the child and the parent(s). For example, the name of the child, the date of birth of the child, and the level of education of the parent were asked. Then the available materials in the home environment were asked. This started with asking about the available literacy material in the household; for example, the number of e-books, digital newspapers and magazines received, and the presence of digital devices. After each response, the interviewer quantified the answers to these questions using a 4-point Likert scale (e.g. 0 / 1 / 2 / >2) and recorded that result.

Next, to measure *formal use of digital literacy material*, we looked at the use of digital devices in the home environment. Not only was the frequency of device use questioned, but also whether this was formal or informal use of the devices. Examples of questions asked include "How often does your child use a smartphone?" and "How often does your child use this specific digital device with educational intentions?". The interviewer quantified the answers to these questions using a 4-point Likert scale (never / sometimes / usually / always) or a 5-point Likert scale (almost never / weekly / a few times a week / daily / a few times a day) and recorded that result.

Then the practice *digital performed literacy activities* were surveyed. Hereby we looked specifically at the type of activity and the proportion of this activity that is performed digitally. The type of activity looked at were literacy activities that were both educational and not, such as reading by oneself, writing by oneself, or letter naming but also activities as rhyme or singing songs, playing language games, looking at picture books and stories to be read aloud. This was done through questions such as: "How often is your child writing?" and "How often does your child use a digital device for this activity?". The interviewer quantified the answers to these questions using a 4-point Likert scale (never / sometimes / usually / always) or a 5-point Likert scale (almost never / weekly / a few times a week / daily / a few times a day). In addition to the questionnaires from Segers et al., (2015; 2020) the parents were in the current study also asked, which applications or software were used for this and which medium was used.

Next, to measure *parents' expectations about their children's early literacy learning*, various components of literacy were questioned by means of statements. Examples of these statements are: "I expect my child to be able to read multisyllabic words correctly at the end of first grade" and "I expect my child to use verbs and conjugations correctly at the end of first grade". The parents could indicate whether they expected their child not to master this at all, to master it a little, to master it sufficiently or to master it completely.

Then, to measure the parental characteristic *parents' attitudes towards their children's literacy learning* this characteristic was questioned by means of five statements such as "Parents are co-responsible for the development of their child's early literacy skills" and "The use of digital support for reading and language activities at home has a positive effect on children's literacy development". *Parents' attitudes towards digitality for literacy learning* were also measured with one item: "The use of digital support for reading and language activities at home has a positive effect on the development of children's reading and language skills". Parents could indicate whether they completely disagreed, slightly agreed or completely agreed. The items that question this parental characteristics, as well as the items that question the parents' modelling behaviour in relation to literacy, are newly added to the questionnaire, compared to the questionnaires used by Segers, Kleemans, and Verhoeven (2015) and Segers and Kleemans (2020).

At last, to measure the parental characteristic *parents' modelling behaviour in relation to literacy*, the parent's own use of digital devices for literacy purposes was questioned. Questions were for example "How often do you read the magazines you received digitally?", and "How often do you use digital devices for purposes other than entertainment?". The interviewer quantified the answers using a 5-point Likert scale (several times a day / daily / weekly / several times a week / structurally not).

Literacy skills

Grapheme-phoneme knowledge

In this task, based on the 'Three Minutes Test and Test for Blending' and 'Grapheme Knowledge Test' (Verhoeven, 1995), all 34 Dutch graphemes were presented to the children one by one on the screen. The children were asked to produce the letter-sounds and not the names of each letter. When children replied with the name of a letter instead of the sound, they were asked for the sound as well. A correct answer would be the correct sound (either as a first answer or after inquiry). The time the child took from the third letter to the last letter was noted by the test taker. Each answer given correctly was worth one point. The total score on this task was the number of correct answers, with a maximum score of 34. The internal reliability of the task was good (Cronbach's $\alpha = .86$). The items of the letters m, s, p, r, n, k, t, aa, z, i, v and h were removed from the inter reliability analysis because these variables had zero variance.

Phonological awareness

Phonological awareness is part of early literacy skills, and stands for the awareness of and ability to work with sounds in spoken language, and is a predictor of later literacy skills (Kilpatrick, 2016). This includes, for example, the skills to be able to analyse the various sounds in a spoken word (segmentation), but also, for example, the skill to be able to form a word when the last letter of the spoken word is removed (deletion). Phonological awareness was therefore operationalised in the current study by means of a segmentation task and a deletion task.

In the *segmentation task*, also used in the study by Schaars, Segers and Verhoeven (2017), the child was asked to serially pronounce each single speech sound of an orally presented word. The task consisted of ten monosyllabic words, increasing in difficulty. The structure of the words went from CVC- structured words to CCVC- or CVCC to words to CCVCC¹- structured words (e.g., the word 'plons'). Each correct answer was worth one point and the total score was a sum of the correct answers given. The maximum score was 10 points. The task was terminated after five consecutive wrong answers, in order to prevent the child's frustration. The inter reliability of the task was acceptable (Cronbach's $\alpha = .71$). Items 1 and 3 were not included in the inter reliability analysis because they had zero variance.

In the *deletion task*, also used in the study by Schaars, Segers and Verhoeven (2017), the child was asked to reproduce 16 named words after the deletion of a indicated letter. For example, the child had to invent and name the word 'dal' without the letter 'd'. The words became more difficult in structure, but also the position of the deleted letter became more and more complicated. For example, the last word of this task, 'strand', the researcher would ask: "What word do I get when I'd remove the r from strand?". The participant had to name the word but without the letter 'r' in it ('stand'). Again, each correct answer was worth one point and the total score was a sum of the correct answers given. The maximum score was 15 points. The task was terminated after five consecutive wrong answers, to prevent the child's frustration. The inter reliability of the task was good (Cronbach's $\alpha = .85$).

Active vocabulary

Though receptive language is most commonly described as an influential aspect of early literacy (e.g., Sénéchal & LeFevre, 2002) online measurement of a receptive language could lead to a fragile reliability of the test results. Therefore, it was decided to assess *active vocabulary* instead. For this purpose, the active vocabulary task from the Clinal Evaluation of Language Fundamentals-4-NL (Semel, Wiig & Secord, 2010) was used. This task has been standardised and tested as sufficiently reliable in terms of internal consistency, test-retest reliability and inter-rater reliability. The validity of this test has also been found sufficient in the literature, as the correlation with the used school results for the validity test by Semel et al., (2010) is between .48 and .79. The test was conducted in line with the official method of administration. Each correct answer was worth two points. Answers that were

¹ C = consonent, V = vowel

partially correct were indicated on the score list and were worth 1 point. The maximum total score of the task was 56. In line with the manual, the task was aborted after seven consecutive wrong answers (i.e., score 0). Children's standardized scores on this task, based on their age at the time of task acquisition were calculated. In line with what was reported, following analysis of the current data the inter reliability of the task proved to be acceptable (Cronbach's $\alpha = .78$). Following analysis, the last item of the task, the Dutch word 'horde' (translation: horde, hurdle, crowd, mob) was removed for the inter reliability analysis, because this item had zero variance.

Procedure

The parents of the children registered their children for participation in this study, with an informed consent. In the months of June to September, a telephone interview with the primary caregiver took place. The interviews with the primary caregiver were conducted via the media of choice of the parents, either telephone ($n = 14$) or video call ($n = 40$). Answers were recorded in the digital script of the interview while the interview took place, which can be found in Appendix A. In order to measure the early literacy and vocabulary skills of the participants, a measurement moment with each participant took place in November ($n = 48$). Due to the COVID-19 pandemic and the measures in place in the Netherlands, this measurement moment took place digitally. The parents were clearly instructed to let their child do the tasks independently.

Data reduction

Preceding analysis in function of the research questions, the data was reduced to meaningful variables. All analyses were completed using the Statistical Package for the Social Sciences (SPSS) programme (IBM Corp., 2012). Mediation analyses were conducted using the PROCESS add-on program in SPSS (Hayes, 2013).

Literacy skills

Based on Sénéchal and LeFevre (2002), we set out to create two variables reflecting the children's language proficiency; children's *early literacy skills* and children's *active vocabulary skills*. As in the study by Segers and Kleemans (2020), the variable *early literacy skills* was derived from children's scores for the tasks of Grapheme-Phoneme Knowledge, Phonological Awareness, including a segmentation task and a phoneme deletion task. Because the distribution of the factor score of the *vocabulary skills* was not normal distributed (kurtosis > 0), this was replaced by the *standardized vocabulary scores*, with a normal distribution. Therefore the raw scores were converted into standardised scores using the standard procedure of the Clinical Evaluation of Language Fundamentals-4-NL (Semel, Wiig & Secord, 2010). To create the factor scores for 1) early literacy skills and 2) vocabulary skills, Principle Component Analysis (PCA) with oblimin rotation and two fixed factors was used. PCA was usable here: KMO 0.72 and Bartlett's Test of Sphericity < 0.05 .

Only components with loadings higher than 0.3 were shown, just as the other times the PCA was performed during this study. (Field, 2009). The PCA confirmed the expected two components, with 76,38 % explained variance (see Appendix B). The variable *early literacy skills* was created using the factor score derived from the PCA with the three underlining tasks (i.e., grapheme-phoneme knowledge, deletion, segmentation). A low score stands for a low level of early literacy skills and a high score means a high level of early literacy skills. The inter reliability of the constructed early literacy skills component was acceptable (Cronbach's $\alpha = 0.72$). For the variable *vocabulary skills*, the factor score of the standardized vocabulary scores, obtained during the PCA, was used.

Formal use of digital literacy material

Formal use of digital literacy material refers to device usage with the intention of literacy learning. To create this variable, first the eight items from the interview representing the use per device were recoded as shown in Table 3, and the items that represent its educational use per device were multiplied with each other. The items in the interview representing the educational use per device were also measured with a four-point scale, increasing from "never" to "sometimes" to "usually" to "always". After this, the eight items that represent the use of TV, PC, tablet, smartphone, e-reader, audio equipment, game consoles or video players were multiplied by the eight items that ask how often this use was formal. After this, 8 new variables were created with the product scores. These scores had a score range from 0 to 9. For example, a score of 9 could be obtained if a device was used daily (value 3) and always for educational purposes (value 3). Multiplying these by each other gave a score of 9. However, because these were product scores, the scores were rearranged as shown in Table 4.

Table 3
Recalibration of product scores for formal use of digital literacy material

Old values	New values	Label
0-2	1	Few to never
3-5	2	On a weekly basis
6-7	3	A few times a week
8-9	4	On a daily basis

In order to create a factor score with these recalibrated items, a PCA with oblimin rotation carried out. Two fixed factors were used because a split between the formal use of devices and the informal use of devices was expected. PCA was usable here: KMO 0.50, Bartlett's Test of Sphericity < 0.05. The variables related to game consoles, e-readers and video players could not be included in the PCA, as they did not show any variance. The PCA confirmed that there were two components, however, the variable reflecting the formal use of the tablet computer loaded negative on both the first and second components. Therefore, the PCA was run again, without the tablet computer variable.

However, this time the variable reflecting formal computer use, loaded on both components. Thus, there appeared to be only one component with 58.43% variance, which included the variables for formal computer use and smartphone use (see Appendix B). It can be assumed that the created variable, consisting of the items 'formal use of the computer', and 'formal use of the smartphone', reflects the *formal use of digital literacy material*. A factor score was calculated for this variable, retrieved from the PCA. A high score for this variable means that children make much formal use of the interactive digital devices. A low value for this variable means that children make little formal use of the devices. However, the inter reliability was unacceptable (Cronbach's $\alpha = 0.14$).

Digital performed literacy activities

To create a variable, first the seven items from the interview that represent frequency of performed activity, were recoded as shown in Table 4.

Table 4

Rescaling for 'digital performed literacy activities'

Old value	Old label	New value	New label
1	Always	1	Never
2	Mostly	2	Sometimes
3	Sometimes	3	Mostly
4	Never	4	Always

The seven variables that indicated the proportion of digital use for these activities, were recoded as shown as in Table 5. Then the items per activity, the frequency for an activity, were multiplied by the ratio of digital output for this activity. This created seven new variables. These scores had a maximum score of 12 and a minimum score of 1. For example, a score of 9 could be obtained if a device was a few times a week (value 3) and when this was carried out mostly digitally (value 3). Multiplying these gave a score of 12. However, because these were product scores, the scores were rearranged as shown in Table 6.

Table 5

Rescaling for the product scores of digital performed literacy activities.

Old value	Old label	New value	New label
1	Almost never	1	Almost never
2	Weekly	2	Weekly
3	A few times a week	3	A few times a week
4	Daily	4	Daily
5	A few times a day	4	Daily

Table 6

Recalibration of product scores for digital performed literacy activities

Old values	New values	Label
1-3	1	Few to never
4-6	2	On a weekly basis
7-9	3	A few times a week
10-12	4	On a daily basis

In order to create a factor score with these recalibrated items, a PCA with oblimin rotation carried out. PCA was usable here: KMO 0.56, Bartlett’s Test of Sphericity < 0.05. The PCA revealed two components, one with educational device activities and one with leisure device activities, but the second component showed only negative values. Therefore, again a PCA was two times performed with one fixed factor, one for the digital activities that were expected to represent educational device activities, resp. frequency of digital self-reading, frequency of digital self-writing and frequency of digital letter naming, and one for the digital activities that were expected to represent leisure literacy activities, including the remaining items. PCA was again usable here: KMO 0.54, Bartlett’s Test of Sphericity < 0.05. This revealed indeed two different components, *digital educational literacy activities*, with 53,9% variance, and *digital leisure literacy activities*, with 41,6% variance (see Appendix B). A high score for this variable, a three or four, means that children frequently carry out digital educational or leisure literacy activities. A low value for this variable, a one or two, means that children infrequently carry out these specific activities. However, the inter reliability of these two new variables were bad (Cronbach's $\alpha = 0.52$ and 0.50).

Parents' expectations about their children's early literacy learning

In order to create a factor score with the ten items that reflected parents' expectations of their child's literacy development at the end of the first Grade, a PCA with oblimin rotation carried out, with one fixed factor. PCA was usable here: KMO 0.78, Bartlett’s Test of Sphericity < 0.05. The PCA confirmed one component with 43,88% explained variance (see Appendix B). This component was called *parents' expectations about their children's early literacy learning*, but includes both literacy and language skills, as language skills can be associated as a part of literacy. A low score for this variable means a low expectation of the parent and a high score means that the parents has high expectations of their child's literacy learning. The inter reliability of the created *parents' expectations about their children's early literacy learning* variable was good (Cronbach's $\alpha = 0.85$).

Parents' attitudes towards their children's literacy learning

In order to create a factor score with the items from the interview that reflected parents' attitudes to the need of literacy support in the home environment, a PCA with oblimin rotation carried out, with one fixed factor. PCA was usable here: KMO 0.61, Bartlett’s Test of Sphericity < 0.05. The PCA confirmed one component, with 54,52% explained variance (see Appendix B), which was called

parents' attitudes towards their children's literacy learning. A factor score was calculated for this component, retrieved from the PCA. A high score for this variable means that the parents are very convinced that the literacy development of children should be stimulated in the home environment and that parents are co-responsible for this. A low score means that parents do not have this attitude and are negative about it. The inter-rater reliability of *parents' attitudes towards their children's literacy learning* was bad (Cronbach's $\alpha = 0.50$).

Parents' attitudes towards digitality for literacy learning

In the interview, parents' opinions on digitality for supporting language and early literacy development were asked with one item which asked parents to respond to the following statement: "Using digital support for reading and language activities at home has a positive effect on the development of children's reading and language skills". The parents were able to express their opinion on the statement using a 4-point Likert scale, where a value of 1 was "totally disagree", and a value of 4 was "totally agree". A high score for this variable means that the parents are very convinced that the digitality is very helpful for the literacy development of children. A low score means that parents do not have this attitude and are negative about it.

Parents' modelling behaviour towards literacy

In order to create a factor score with the items from the interview that reflected parents' attitudes to the need of literacy support in the home environment, a PCA with oblimin rotation carried out, without fixed factors. PCA was usable here: KMO 0.60, Bartlett's Test of Sphericity < 0.05 . The scree plot indicated that there were two components, with 56.36% explained variance. Based on literature (Sénéchal & LeFevre, 2002), it could be concluded that the first variable, consisting of the items 'frequency of using digital resources for purposes other than entertainment' and 'frequency of reading digital newspapers' reflects *parents' modelling behaviour in relation to literacy for education*. A factor score was calculated for this variable, retrieved from the PCA. A high score for this variable means that parents show modelling behaviour in which the parent very frequently uses digital literacy resources for purposes other than entertainment. A low value for this variable means that the parents show infrequent modelling behaviour in which the parent uses digital literacy resources in a formal way.

On the other hand, the second component, consisting of the items 'frequency of reading digital magazines' and 'frequency of reading e-books' reflects *parents' modelling behaviour in relation to literacy for leisure*. There was also a factor score calculated for this variable, retrieved from the PCA. A high value means that the parents themselves regularly use literacy resources for leisure purposes and thus show high frequency modelling behaviour in this. A low value, on the other hand, means that the parents do not often use literacy tools for leisure purposes. For both components the inter reliability was unacceptable (Cronbach's $\alpha < 0.50$).

Data-analysis

Before starting the statistical analyses (i.e., correlation, multiple regression and mediation analyses), a check was made as to whether the data complied with the conditions. Apart from the fact that the normality assumption could not be met for all variables, no peculiarities were found. However, factor scores can generally be assumed to approximate a normal distribution, and may therefore be treated as such for further analyses (Field, 2009). Details of the analysis can be found in Appendix C.

Results

Descriptive statistics

The research question of the study addressed the impact of the different aspects of Digital Home Literacy Environment (DHLE), on early literacy skills and vocabulary skills. Table 7 shows the descriptive statistics for the variables under study, two dependant variables, and eight expected predictors. All ten variables under study were factor scores, but to give a better insight into the distribution of the literacy skills in the sample for early literacy skills and vocabulary skills sum scores for each subtest are also provided. To foster sense making, for each factor score the underlying variables and their descriptive statistics are also presented.

Table 7

Descriptive statistics of the study variables in factor scores and the raw scores of the corresponding items

Variables	<i>n</i>	<i>M</i>	<i>SD</i>	Min	Max
1. Early literacy skills	48	0.00	1.00	-2.00	1.51
<i>Grapheme-phoneme knowledge task score</i>	48	29.63	3.77	20	34.00
<i>Deletion task score</i>	48	6.90	4.00	0.00	15.00
<i>Segmentation task score</i>	48	7.54	1.98	4.00	10.00
2. Vocabulary skills	48	0.00	1.00	-2.63	2.05
<i>Vocabulary score</i>	48	31.06	8.03	9.00	46.00
3. Formal use of digital literacy material	48	0.00	1.00	-1.70	3.94
<i>Formal use of the computer</i>	48	1.33	0.83	1.00	4.00
<i>Formal use of the smartphone</i>	48	1.04	0.20	1.00	2.00
4. Digital performed literacy activities: educational literacy activities	48	0.00	1.00	-1.84	2.36
<i>Digital self-reading*</i>	48	1.69	0.62	1.00	3.00
<i>Digital writing*</i>	48	1.85	0.58	1.00	3.00
<i>Digital letter naming*</i>	48	2.06	0.72	1.00	4.00
5. Digital literacy activities: leisure literacy activities	48	0.00	1.00	-1.83	2.31
<i>Reading aloud using e-books*</i>	48	2.21	0.71	1.00	4.00
<i>Looking at digital picture books*</i>	48	1.83	0.60	1.00	3.00
<i>Digital rhyming or singing*</i>	48	1.81	0.94	1.00	4.00
<i>Playing digital language games*</i>	48	1.77	0.90	1.00	4.00
6. Parents' expectations about their children's literacy learning	48	0.00	1.00	-3.07	1.05
7. Parents attitudes to their children's literacy learning	48	0.00	1.00	-2.26	0.98
8. Parents' attitudes towards digitality for literacy learning	48	0.00	1.00	-2.30	2.46
9. Parents' modelling behaviour in relation to literacy for education	48	0.00	1.00	-2.16	1.71
10. Parents' modelling behaviour in relation to literacy for leisure	48	0.00	1.00	-1.07	2.96

*1 = few to never /2 = weekly/3 = few times a week/4 = daily

Results of data analysis

To answer the research question “*To what extent do the different aspects of the digital home literacy environment predict the early literacy and vocabulary skills of first-graders?*” and to be able to accept or reject the corresponding hypotheses, two multiple linear regression analyses were conducted. The first analysis was conducted to create a predictive model for early literacy skills, and the second analysis was conducted to create a predictive model for vocabulary skills. In both analyses, the enter method was used. The results of the corresponding Spearman rank-order correlation analysis can be found in Table 8. The effect sizes for the results of the multiple regression analyses will be expressed in f^2 , as described by Cohen (1988). Effect sizes around .02 are therefore considered as small, effect sizes around .15 as moderate and effect sizes around .35 or above as large.

Table 8

Bivariate correlations of the ten study variables (Spearman)

Variable	1	2	3	4	5	6	7	8	9	10
1. Early literacy skills	-									
2. Vocabulary skills	.27	-								
3. Formal use of digital literacy material	-.16	.06	-							
4. Digital performed literacy activities: educational literacy activities	-.12	.02	-.16	-						
5. Digital performed literacy activities: leisure literacy activities	-.14	0.35**	.07	.13	-					
6. Parents' expectations about their children's literacy learning	.53*	.46*	-.07	.05	.09	-				
7. Parents attitudes to their children's literacy learning	-.03	-.07	.09	.19	.10	-.30	-			
8. Parents' attitudes towards digitality for literacy learning	-.21	-.10	-.07	.08	-.01	-.27	.20	-		
9. Parents' modelling behaviour in relation to literacy for education	.10	.12	-.41**	.20	-.31	-.17	.23	.02	-	
10. Parents' modelling behaviour in relation to literacy for leisure	.01	.10	.29*	-.10	-.04	-.04	.29	.06	.01	-

$N = 48$, * $p < .05$, ** $p < .01$

For the first multiple regression analysis, early literacy skills was the dependent variable and the eight created variables (variables 3-10 in Table 8) were the independent variables. For the second multiple regression analysis, vocabulary skills was the dependant variable and the same eight variables were the independent variables. The explanatory model for early literacy, explained 26,2% of the variance in the children's early literacy skills ($p = .023$). The effect size, $f^2 = .35$, was large. Furthermore, the explanatory model for vocabulary skills, explained 24.8% of the variance in the children's vocabulary skills ($p = .032$). The effect size, $f^2 = .32$, was large. The results of both analyses were shown in Table 9. In the following paragraphs, the results from the two regression analyses will be used to explain the found results for hypotheses.

Table 9

Predicting models for early literacy (left) and vocabulary skills (right), obtained by two separate multiple regression analyses

Independent variable	Early literacy skills				Vocabulary skills			
	β	SE	95% CI		β	SE	95% CI	
			LL	UL			LL	UL
Formal use of digital literacy material	-.276	.145	-.568	.017	.043	.146	-.252	.338
Digital performed literacy activities: education	-.124	.128	-.384	.135	.003	.130	-.259	.265
Digital performed literacy activities: leisure	-.210	.129	-.470	.050	.319*	.130	.056	.581
Parents' expectations about their children's literacy learning	.538**	.132	.270	.806	.398**	.134	.128	.668
Parents' attitudes towards digitality for literacy learning	-.105	.129	-.366	.155	-.041	.130	-.304	.222
Parents' attitudes towards their children's literacy (learning).	.202	.132	-.065	.469	-.047	.133	-.316	.223
Parents' modelling behaviour in relation to literacy for education	-.125	.136	-.399	.150	.340*	.137	.063	.617
Parents' modelling behaviour in relation to literacy for leisure	.141	.135	-.132	.414	.145	.145	-.131	.420
R^2	.408**				.396**			
Adjusted R^2	.286**				.272**			

$N = 48$. CI = confidence interval. * $p < .05$. ** $p < 0.01$

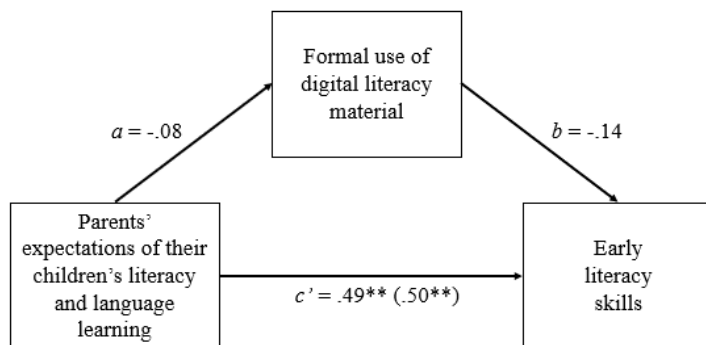
First, it was expected that the frequency of children's formal use of digital devices for performing literacy activities would have a positive effect on early literacy skills and vocabulary skills. The two multiple regression analyses showed that formal use of digital literacy material was not a significant predictor of early literacy skills or vocabulary skills (see Table 9).

Second, it was expected that children's digital performance of literacy activities would have a positive effect on early literacy and vocabulary skills of first graders. To examine this, the performed literacy activities were divided in digital educational literacy activities and digital leisure literacy activities. The predictive model for early literacy skills showed that both digital educational literacy activities and leisure literacy activities were not significant predictors of early literacy skills. For vocabulary skills, only digital leisure literacy activities proved to be a significant predictor (see Table 9). The effect size, $f^2 = .15$, was moderate.

Third, it was expected that parents' expectations about their children's literacy learning would have a relationship with early literacy and vocabulary skills, mediated via the formal use of digital literacy material. The two predictive models showed that that parents' expectations of their children's literacy learning was a significant predictor for early literacy skills and vocabulary skills (see Table 9). The effect sizes, resp. $f^2 = .38$ and $f^2 = .27$, were large. To examine the expected indirect relationship, two mediation analyses were carried out. Hereby were early literacy and vocabulary skills the dependent variables, parents' expectations about their children's literacy learning was the independent variable, and formal use of digital literacy material was the mediator. Following Hayes' (2013) recommendation, boot-strapping was set at 5000 cycles and the used model number was 4. The first mediation analysis showed that there was no significant indirect effect from parents' expectations about their children's literacy learning on early literacy skills, *via* formal use of digital literacy material (95% CI -0.02, - 0.07). The R^2 of the final model of this mediation analysis was .26 and significant, $F(2, 45) = 8.29, p < 0.001$. The overall effect of parents' expectations about their children's literacy learning on early literacy skills was found to be positive and significant, $b = .49, t(46) = 3.83, p < .001$ (path c). However, there appeared to be no effect of formal use of digital literacy material on early literacy skills (path b) $b = -.14, t(46) = -1.07, p = .29$, or of parents' expectations about their children's literacy learning on formal use of digital literacy material (path a), $b = -.08, t(46) = -0.53, p = .60$. This mediation model is shown in Figure 4.

Figure 4

Mediation model of parents' expectations about their children's literacy learning on early literacy skills

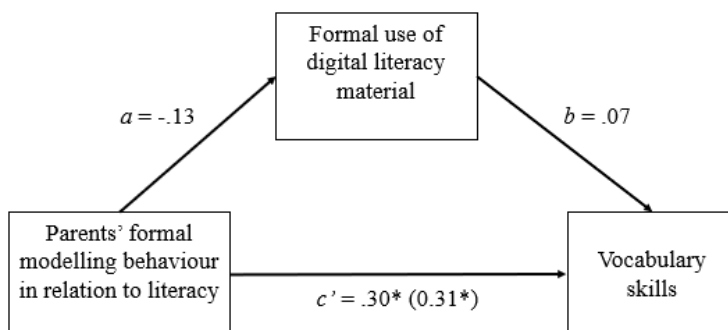


Note. This figure demonstrates the total, direct and indirect effects of parents' expectations about their children's literacy learning on early literacy skills, *via* formal use of digital literacy material. Between brackets is the total effect (c), outside the bracket direct effect (c'). *Note* ** $p < .05$

The second mediation analysis of parents' expectations about their children's literacy learning and vocabulary skills, showed that there was no significant indirect effect from parents' expectations of their children's literacy learning on vocabulary skills, *via* formal use of digital literacy material (95% CI $-0.06, -0.04$). The R^2 of the final model of this mediation analysis was .19 and significant, $F(2, 45) = 5.47, p = 0.007$. The total effect of parents' expectations on vocabulary was positive and significant, $b = .44, t(46) = 3.30, p = .002$ (path c). However, there was no effect of formal use of digital literacy material on vocabulary skills (path b), $b = .06, t(46) = 0.46, p = .651$, or of parents' expectations on formal use of digital literacy material (path a), $b = -.08, t(46) = -0.53, p = .601$. The mediation model of this analysis is shown in Figure 5.

Figure 5

Mediation model of parents' expectations about their children's literacy learning, on vocabulary skills



Note. This figure demonstrates the total, direct and indirect effect of parents' expectations about their children's literacy learning on vocabulary skills, *via* formal use of digital literacy material. Between brackets is the total effect (c), outside the bracket direct effect (c'). *Note* * $p < .05$

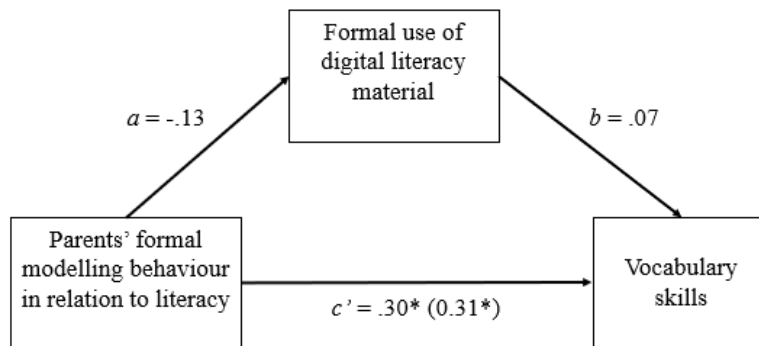
Fourth, it was expected that parents' attitudes towards their children's literacy learning would have a relationship with the children's early literacy and vocabulary skills of first graders, mediated via formal use of digital literacy material. The two predictive models showed that parents' attitudes towards their children's literacy learning and parents' attitudes towards digitality for literacy learning were both not a significant predictor of early literacy skills or vocabulary skills (see Table 9). In the absence of these direct effects, indirect relationships with these two independent and dependent variables *via* formal use of digital literacy material was ruled out. Mediation analyses with these variables was therefore not carried out.

Fifth, it was expected to find only a direct relationships between parents' own modelling behaviour towards literacy and early literacy and vocabulary skills. To examine this hypothesis, the modelling behaviour of parents in relation to literacy was broken down in two variables: parents' modelling behaviour in relation to literacy for education and parents' modelling behaviour in relation to literacy for leisure. The two predictive models showed that parents' modelling behaviour in relation to literacy for leisure was not a significant predictor of early literacy skills or vocabulary skills. In addition, the predictive models for early literacy skills and vocabulary skills showed that parents' modelling behaviour in relation to literacy for education was only a predictor of vocabulary skills (see Table 9). The effect size, $f^2 = .19$, was moderate.

In order to examine whether the relationship with vocabulary skills was indeed only direct, and not indirect *via* formal use of digital literacy material, a mediation analysis was carried out. Hereby, the dependent variable was vocabulary skills, the independent variable was parents' modelling behaviour in relation to literacy for education, and the mediator was formal use of digital literacy material. Following Hayes' (2013) recommendation, boot-strapping was set at 5000 cycles and the used model number was 4. This mediation analysis showed that there was no indirect effect (95% CI - 0.04, 0.08). The R^2 of the final model of this mediation analysis was .08 and not significant, $F(2, 45) = 2.12, p = .131$. As can be seen in Figure 6, only the total effect of parents' modelling behaviour in relation to literacy for education on vocabulary was positive and significant (path c). There was no effect of formal use of digital literacy material on vocabulary skills (path b), $b = .07, t(46) = 0.46, p = .542$, or of parents' modelling behaviour in relation to literacy for education on formal use of digital literacy material (path a), $b = -.13, t(46) = -0.53, p = .49$. The mediation model of this analysis is shown in Figure 6.

Figure 6

Mediation model of parents' modelling behaviour in relation to literacy for education, on vocabulary skills



Note. This figure demonstrates the total, direct and indirect effect of *parents' modelling behaviour in relation to literacy for education* on vocabulary skills, *via* formal use of digital literacy material. Between brackets is the total effect (c), outside the bracket direct effect (c'). *Note* * $p < .05$

Discussion

The purpose of this study was to gain a better understanding of the Digital Home Literacy Environment (DHLE) and how the various aspects relate to the early literacy and vocabulary skills of first graders. More specifically, it was investigated whether the digital counterparts of known analogue predictors of early literacy and vocabulary skills, had similar predictive values. Minimal similarities between the analogue HLE and the DHLE, in regard to the predictive value for early literacy and vocabulary skills, were found.

Formal use of digital literacy material

In contrast to what was expected based on common HLE models (Sénéchal & LeFevre, 2002), outcomes of the current study showed no predictive value of the frequency of digital formal literacy activities on early literacy or vocabulary skills. An explanation for the missing effects of formal use of digital literacy material on both early literacy skills and vocabulary skills could be that the quality of the DHLE is too limited to be able to demonstrate effects. This means that children do not yet make much formal use of digital equipment to carry out literacy activities. For example, on average the sample made little or no formal use of computers or smartphones, with minimal variation. Specific in view of the missing effect on vocabulary skills, it is possible that this limited use means that there has been too little repetition to anchor new words in the child's mental lexicon, since the consolidation of a new word requires frequent repetition (Schaerlaekens, 2008).

Another explanation for the lack of predictive value for vocabulary skills could be the fact that the children in the sample generally come from families with highly educated parents, and thus probably grow up in a rich language environment with a lot of qualitative language supply (e.g., Bernstein, 2003; Cartmill, 2016; Hoff, 2003). As digital formal literacy activities would be expected to be particularly effective for language-poor home environments, where digitisation could supplement the lack of language provision by parents, the expected effect may not be present in this sample.

Digital performed literacy activities

Of the digital performed literacy activities, specified in *digital educational literacy activities* (self-writing, self-reading or letter naming) and *digital leisure literacy activities* (e.g. language games, digital story telling or looking at digital picture books), the results partially align with the expectation that digital literacy activities, such as digital picture book viewing or digital storytelling, contribute to children's language development. This finding complements previous studies that show a similar relation (Herodotou, 2018; Teepe et al., 2017). Though it was expected that both leisure as well as more educational activities would have predictive value for both skills (vocabulary and literacy). The current study only provided proof for the predictive value of leisure activities for vocabulary skills. Neither category of activities demonstrated predictive value for literacy skills.

That leisure activities predicts one but not the other could be a result of the difference in interactions required for the successful acquisition of early literacy skills versus vocabulary. It can be that the type of activity that children engage in during digital leisure activities aligns better with the activities required to develop vocabulary versus literacy skills (i.e., grapheme-phoneme knowledge, deletion and segmentation skills). Leisure literary activities, such as language games or digital storytelling, are directly concerned with practising vocabulary, whereby words are repeated frequently and thus consolidated (e.g. Herodotou, 2018; Schaerlaekens, 2008; Sénéchal & LeFevre, 2002; Teepe et al., 2017), which has a direct effect on the child's vocabulary.

Following this line of reasoning one would expect that educational activities predict early literacy skills, but this effect could not be found in the present study. One explanation could be that the effect was not measurable as the children in this study were relatively young and were still in the early months of instruction-based literacy education in first grade. It is possible that the children therefore did not yet have the literacy level of automated reading that is needed to see differences in complex literacy skills such as segmentation and deletion (Gates et al., 2009; Geudens et al., 2004). Therefore, it could be that the effect of digital leisure activities on literacy skills, is only detectable at a later age, when basic reading skills are already automated. Future research could focus on children that have more advanced reading skills to check whether such effects for literacy skills can be established then.

A more methodological explanation for the missing proof for the predictive value of both digital performed literacy activities on early literacy in the current study may be a result of measurements used to establish literacy skills in the current study. For example, Neumann (2016) did establish predictive value of digital writing activities with several unique sub components of early literacy (e.g., print awareness, print knowledge and grapheme-phoneme knowledge). But, in contrast to Neumann's study (2016), the current study used a single dependent variable for early literacy skills, making any association with specific sub-components of early literacy undetectable. As for another example, in contrast to the current study, Lehl et al. (2021), measured children's literacy skills based on parental perception and estimation, rather than testing their children's actual skills. These parental assessments may provide a distorted view of the actual skills of the children, due to the social desirability of the parents (Boudreau, 2005).

Parental characteristics

Parents' expectations about their children's literacy learning

It was expected that parents' expectations about their children's literacy learning would be a direct and indirect predictor of early literacy and vocabulary *via* formal use of digital literacy material. However, consistent with the findings of Segers and Kleemans (2020), *only* a direct relationship could be found. As Segers and Kleemans (2020) pointed out in their study, the lack of a mediation relationship could be explained by the fact that Dutch parents are generally highly aware of the importance of literacy activity in the home environment (McElvany et al., 2012), and implementation of these activities is unlikely to be related to the expectation parents have of their children. The data from the current study showed that the parents from the participant group were very positive about literacy stimulation in the home environment. The parents also saw the added value of using digital tools for literacy activities. These facts make the earlier explanation by Segers and Kleemans (2020) for the lack of mediation also very plausible for the current study.

Parents' attitudes towards literacy learning and digitality for literacy learning

It was expected that parents' attitudes, both towards literacy learning and towards digitality for literacy learning, would be an indirect predictor of early literacy and vocabulary *via* formal use of digital literacy material. In contrast to common HLE models (Nag et al., 2019), outcomes of the current study show no predictive value of parents' attitudes on early literacy and vocabulary skills. An explanation could be that the expected mediation relationship *via* formal use of digital literacy material, does not exist in Dutch households. As described above, parents are generally very aware of the importance of literacy activities in the home environment (McElvany et al., 2012). The results of the present study showed this same general positive attitude of parents, which makes a relationship with the actual performance of literacy activities unlikely.

Despite the found positive attitudes towards literacy learning in the home environment and the use of digitality for this purpose, the implementation of formal digital literacy activities was lacking. This discrepancy can possibly be explained by a Dutch cultural reason. In the Netherlands, there are many prominent recommendations to minimise screen time for children, for example to prevent myopia, obesity, social problems or sleeping problems. Moreover, the World Health Organisation (WHO) recommends that children up to the age of 6 should have no more than one hour of screen time a day (NOS, 2022). Given that this hour also includes entertainment use, it is plausible that use for literacy stimulation is compromised, thus making it plausible that the minimum output of digital literacy activity is not due to unwillingness or negative attitudes on the part of the parent.

Parents' modelling behaviour towards literacy

Although it was expected that no predictive value of parents' modelling behaviour towards literacy would be found for early literacy or vocabulary, results showed parents' modelling behaviour in relation to literacy for education as a direct predictor for vocabulary. No such effect could be found for early literacy skills. This discrepancy may be explained by the fact that parents who frequently use digital literacy materials in a more educational way, such as reading digital newspapers, are likely to develop a richer vocabulary, as has been proven for analogue newspaper reading (Cunningham & Stanovich, 1998). It is plausible that this richer parental vocabulary is automatically implemented in the language offerings in the child's linguistic home environment and that this richer linguistic environment, in addition to stimulating language activities, will influence the breadth of a child's vocabulary (Hart & Risley, 1995). Finally, the results showed that parents' modelling behaviour in relation to literacy for education as well as for leisure, were both not predictors for vocabulary and early literacy skills. These results confirm the assumption that the parent's model of behaviour will not lead a child to engage in a digital literacy activity because the device masks the type of activity that parents perform on the device.

Limitations

It should be noted that this study has been conducted during the first COVID-19 waves, which had some implications the data collection method. This meant that literacy measurements had to take place digitally, by means of videocalls. In addition, the various literacy and vocabulary tests had to be made suitable for digital testing. For example, instead of measuring the passive vocabulary, as in the studies on the analogue HLE (e.g., Martini & Sénéchal, 2012; Nag et al., 2019; Silinskas et al., 2020; Sénéchal & LeFevre, 1998), it was decided to measure the active vocabulary in the current study because it was more reliable for digital testing. In addition, the pandemic, in which Dutch primary schools were not accessible due to the COVID-19 rules in place, made it difficult to recruit participant for this study. As a result, the sample size of this study was relatively small, with the vast majority of parents being highly educated and almost all children scoring high on both early literacy tasks and the vocabulary task. This leaves out a part of society that, for example, grows up in a language-poor environment or with parents who themselves do not have sufficient capacity to offer analogue literacy exercises at home. It was expected that the introduction of digitality in the home literacy environments, where children could practice literacy independently and qualitatively, would be most beneficial for this group of society. Therefore, the results of this study should be interpreted and generalised with caution.

Conclusion and Recommendations

The current study investigated whether the relationships of the known models of the analogue HLE were also reflected in the DHLE. In general, a moderately qualitative DHLE was found, in which no predictive value for early literacy could be found. The conclusion of this study therefore dovetails with Segers and Kleemans (2020), who concluded that a high quality HLE is needed to be able to demonstrate the possible effects of the different facets of the DHLE. The current study has established that digitality, with its numerous possibilities for the stimulation of literacy, has not taken over the HLE. The use of digitality is so far only a possible supplement for the analogue HLE. The study showed the presence of direct predictive values of parental characteristics for early literacy and vocabulary skills, but indirect relationships via the DHLE could not be found.

Murray and Olcese (2011) already indicated that digital technology was being underused for educational purposes by parents and carers. The minimal formal digital activity of the participants of this current study is noteworthy, as it suggests that in almost 10 years, despite all the developments and attention paid to the subject, the use of digital technology has improved minimally. Moreover, the participant group had relatively well-educated parents who generally believed very strongly in the potential of digital devices to stimulate literacy, and who had sufficient devices at their disposal in the home environment. Many of these parents indicated that they often did not know what their child was actually doing on a device, or which educational apps they could offer. Therefore, a practical implication to optimise the potential of the DHLE in the future, is to inform and instruct the parents, teachers and caregivers, as willing adapters. In this way, children and their parents can make conscious use of the many high-quality educational apps or software available in the future.

Finally, this study showed that the old analogue HLE model still exists in many households. The DHLE is to date only complementary to the analogue HLE and it is therefore necessary to investigate these models together. In this way, a single predictive model can be created that incorporates both the analogue and digital aspects. Moreover, it is recommended that future research identifies what factors might lead to the current minimal digital implementation of literacy activities in the (D)HLE. More attention is needed to map out this part of the digital society, which is likely to continue to digitise, as children grow up with promising literacy tools at their fingertips. It is important to map out the opportunities and threats in this regard, before knowledge about it will irrevocably lagging behind.

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Appendix A: Questionnaire used in the interview in Dutch

Wat is de naam van uw kind dat na de zomer zal starten in groep 3?

Voornaam (1) _____

Achternaam (2) _____

Zou u [naam] omschrijven als jongen, meisje of anders?

jongen (1)

meisje (2)

anders (3) _____

Wat is de geboortedatum van [naam]? (dd/mm/yyyy)

Naar welke school gaat [naam] komend schooljaar?

Naam school (1) _____

Plaats (2) _____

Is dit dezelfde school als afgelopen jaar?

Zo nee, naar welke school ging [naam] afgelopen jaar?

Ja (1)

Nee, dat was (naam, plaats): (2) _____

Wat is uw relatie met [naam] ?

- vader (1)
- moeder (2)
- anders (verzorger, pleegouder, opa/oma) (3)
-

Wat is uw:

- geboortemaand (1) _____
- geboortjaar (2) _____

Wat is uw hoogst genoten afgeronde opleiding?

- Basisonderwijs (1)
- Middelbaar onderwijs, namelijk (Mavo, Havo, Vwo, Ivbo, Lts, VMBO): (2)
-
- Middelbaar beroepsonderwijs (MBO) (3)
- Hoger beroepsonderwijs (HBO) (4)
- Universiteit (5)

Wonen er behalve u nog andere opvoeders in huis?

- ja, namelijk (vader, moeder, opa, oma, stiefvader/moeder): (1)
-
- nee (2)

Wat is de hoogst genoten afgeronde opleiding van de andere opvoeder(s)?

- Basisonderwijs (1)
- Middelbaar onderwijs, namelijk (Mavo, Havo, VWO, Lts, Ivbo, VMBO): (2)
-
- Middelbaar beroepsonderwijs (MBO) (3)
- Hoger beroepsonderwijs (HBO) (4)
- Universiteit (5)

Wonen er ook andere kinderen in huis? Zo ja, hoeveel?

- ja, namelijk (1) _____
- nee (2)

Wat zijn de leeftijden van de andere kinderen?

Hoeveel dagdelen gaat [naam] naar de kinderopvang?

Heeft u een vitaal beroep en had u daardoor tijdens de intelligente lock-down (ivbm corona, maart/april 2020) recht op kinderopvang?

- vitaal beroep ja (1)
- vitaal beroep nee (2)
- recht op kinderopvang ja (3)
- recht op kinderopvang nee (4)

In welke mate heeft u gebruik gemaakt van dit recht op kinderopvang?

- meer dan normaal (1)
- net zoveel als normaal (2)
- minder dan normaal (3)
- helemaal niet (4)

In welke taal wordt het onderwijs op school aangeboden?

- Nederlands (1)
- Engels (2)
- Anders, namelijk: (3) _____

Is de taal waarin het onderwijs op school wordt aangeboden hetzelfde als de taal die thuis wordt gesproken?

- Altijd (1)
- Meestal (2)
- Soms (3)
- Nooit (4)

Welke taal wordt thuis gesproken?

Ontvangt uw kind, buiten school, onderwijs in zijn/haar thuistaal?

- Altijd (1)
- Vaak (2)
- Soms (3)
- Nooit (4)

Op hoeveel kranten heeft u thuis een abonnement?

En op hoeveel tijdschriften?

	0 (1)	1 (2)	2 (3)	>2 (4)
kranten (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
tijdschriften (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Hoe vaak krijgt u deze kranten als drukwerk thuisgestuurd? En hoe vaak leest u deze?

Hoe vaak ontvangt u kranten digitaal? En hoe vaak leest u deze?

Hoe vaak krijgt u deze tijdschriften als drukwerk thuisgestuurd? En hoe vaak leest u deze?

Hoe vaak ontvangt u tijdschriften digitaal? En hoe vaak leest u deze?

Hoe vaak leest u boeken (gedrukt)?

Hoe vaak leest u e-books?

Hoe vaak gebruikt u digitale middelen met een ander doel dan entertainment? (denk aan het opzoeken van informatie, nieuws, instructie etc.)

	Meerdere per dag (1)	Dagelijks (2)	Paar keer per week (4)	Wekelijks (3)	niet structureel/nvt (5)
Kranten (drukwerk) ontvangen (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Kranten (drukwerk) lezen (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Kranten (digitaal) ontvangen (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Kranten (digitaal) lezen (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tijdschriften (drukwerk) ontvangen (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tijdschriften (drukwerk) lezen (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tijdschriften (digitaal) ontvangen (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Tijdschriften (digitaal) lezen (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Boeken (gedrukt) lezen (10)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
E-books (digitaal) lezen (11)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
gebruik digitale middelen (niet entertainment) (9)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Hoeveel gedrukte boeken heeft u in huis?

En tot hoeveel digitale boeken/e-books heeft uw huishouden toegang?

	0-10 (1)	10-25 (2)	25-100 (3)	>100 (4)
Boeken (drukwerk) (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Boeken (digitaal) (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Hoeveel bibliotheekpassen/abbonementen heeft uw gezin?

	0 (1)	1 (2)	2 (3)	>2 (4)
bibliotheekpassen (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Hoe vaak gaat u met [naam] naar de bibliotheek?

	dagelijks (1)	paar keer per week (2)	wekelijks (3)	1 of 2 keer per maand (4)	vrijwel nooit (5)
bibliotheekbezoek (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Ik ga enkele digitale apparaten noemen.

Ik wil u vragen om per apparaat aan te geven hoeveel er in uw huishouden aanwezig zijn (geen, 1, 2 of meer dan 2)

Apparaat	Aantal in huis			
	0 (0)	1 (1)	2 (2)	>2 (3)
Televisie				
Computer of laptop				
Tablet (I-Pad, Samsung Tab)				
Smartphone				
E-reader				
Audio apparatuur				
On-demand streamingsdiensten				
Spelcomputers				
videospelers				

Hoe vaak gebruikt uw kind elk apparaat? Ik verzoek u hierbij te denken aan de afgelopen maanden (mei/juni).

Apparaat	Hoe vaak gebruikt [naam] deze?				
	Vrijwel nooit (1)	Wekelijks (2)	Paar keer per week (3)	Dagelijks (4)	Paar keer per dag (5)
Televisie					
Computer of laptop					
Tablet (I-Pad, Samsung Tab)					
Smartphone					
E-reader					
Audio apparatuur					
On-demand Streamingsdiensten					
Spelcomputers					
Videospelers					

In welke mate is het gebruik van dit specifieke apparaat voor onderwijs gerelateerd gebruik? Ik verzoek u hierbij te denken aan de afgelopen maanden (mei/juni).

Apparaat	Hoe vaak is dit gebruik onderwijsgerelateerd?			
	Altijd (1)	Meestal (2)	Soms (3)	Nooit (4)
Televisie				
Computer of laptop				
Tablet (I-Pad, Samsung Tab)				
Smartphone				
E-reader				
Audio apparatuur				
On-demand streamingsdiensten				
Spelcomputers				
Videospelers				

Heeft u een regel wat betreft schermtijd?

Zo ja, wat is deze?

nee (1)

ja, namelijk (2) _____

Zijn de regels wat betreft het gebruik van digitale middelen tijdens corona (periode april - juni) anders dan daarvoor?

Zo ja, kunt u de verschillen beschrijven?

nee (1)

ja, namelijk: (2) _____

Ik ga nu een aantal activiteiten opnoemen, kunt u per activiteit aangeven of u dit: vrijwel nooit/wekelijks/een paar keer per week/dagelijks of paar keer per dag doet?

	vrijwel nooit (1)	wekelijks (2)	paar keer per week (3)	dagelijks (4)	paar keer per dag (5)
Hoe vaak stimuleert u [naam] om te lezen? (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hoe vaak stimuleert u [naam] om te schrijven? (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hoe vaak speelt u taal- of woordspelletjes met [naam]? (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hoe vaak oefent u samen met [naam] taalversjes, liedjes en rijmpjes? (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hoe vaak leest u [naam] voor of bekijkt u samen prentenboeken? (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Hoe vaak gebruikt u bij dergelijke activiteiten leermiddelen die de school u aanbiedt? (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Als u bovengenoemde activiteiten met [naam] doet, in welke mate is uw doel dan om [naam] iets te leren?

- Altijd (1)
- Meestal (2)
- Soms (3)
- Nooit (4)

Activiteit	Hoe vaak is [naam] hiermee bezig?				
	Vrijwel nooit (1)	Wekelijks(2)	Een paar keer per week (3)	Dagelijks (4)	Een paar keer per dag (5)
Voorlezen / naar verhalen luisteren (1)					
Zelf lezen (2)					
Zelf schrijven (3)					
Taal- en woordspelletjes (4)					
Taalversjes, liedjes en rijmpjes (5)					
Bekijken van prentenboeken (6)					
Benoemen van letters (7)					

Activiteit	Hoe vaak gebruikt [naam] voor deze activiteiten digitale middelen?				
	Vrijwel nooit(1)	Wekelijks (2)	Paar keer per week (3)	Dagelijks(4)	Paar keer per dag(5)
Voorlezen / naar verhalen luisteren (1)					
Zelf lezen (2)					
Zelf schrijven (3)					
Taal- en woordspelletjes (4)					
Taalversjes, liedjes en rijmpjes (5)					
Bekijken van prentenboeken (6)					
Benoemen van letters (7)					

Ik ga enkele activiteiten noemen die te maken hebben met het oefenen van lees- en schrijfvaardigheid. Ik vraag u per activiteit aan te geven hoe vaak [naam] met deze activiteit bezig is en hoeveel van deze activiteit uitgevoerd wordt met behulp van digitale middelen. Wanneer deze activiteit inderdaad digitaal wel eens beoefend wordt, zal ik u vragen op een beschrijving van dit gebruik. Ik verzoek u bij de activiteiten te denken aan de afgelopen periode (mei/juni).

Activiteit	Beschrijving van de digitale activiteit		
	Naam applicatie	Gebruikte medium	Zelfstandig gebruik of samen met ouder
Voorlezen / naar verhalen luisteren (1)			
Zelf lezen (2)			
Zelf schrijven (3)			
Taal- en woordspelletjes (4)			
Taalversjes, liedjes en rijmpjes (5)			
Bekijken van prentenboeken (6)			
Benoemen van letters (7)			

Is de mate waarin [naam] met deze activiteiten bezig is tijdens corona (april-juni) anders dan daarvoor?

Zo ja, kunt u de verschillen beschrijven?

Ik ga u nu een aantal stellingen voorleggen. Ik wil u vragen om per stelling aan te geven of u het er helemaal niet / amper / een beetje / of helemaal mee eens bent.

	helemaal niet mee eens (1)	amper (2)	een beetje (3)	helemaal mee eens (4)
Ouders/verzorgers zijn medeverantwoordelijk voor de ontwikkeling van de lees- en taalvaardigheid van hun kind. (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Ouders/verzorgers zijn moeten thuis activiteiten doen om bij te dragen aan de ontwikkeling van de lees- en taalvaardigheid van hun kind. (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Het is nodig dat ik buiten school extra aandacht besteed aan de lees en taalvaardigheid van mijn kind. (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Het gebruik van digitale ondersteuning bij lees- en taalactiviteiten thuis heeft een positief effect op de ontwikkeling van lees- en taalvaardigheid van kinderen. (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Niet digitaal ondersteunde lees- en taalactiviteiten thuis hebben een positief effect op de ontwikkeling van lees- en taalvaardigheid. (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Ik verwacht dat [naam] eind groep 3

	helemaal niet (1)	een beetje (2)	voldoende (3)	geheel (4)
alle letters (fonemisch) kan benoemen en schrijven (1)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
korte klankzuivere woorden foutloos en vlot kan lezen (bijv. krant, stronk, plant) (2)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
korte klankzuivere woorden zelfstandig kan schrijven (bijv. krant, stronk, plant) (3)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
woorden met afwijkende spellingspatronen correct kan lezen (bijv. flat, poster) (4)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
meerlettergrepige woorden correct kan lezen (bijv. bloempot, blokken, ballon) (5)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
een simpele korte tekst vloeiend met de juiste intonatie kan lezen (6)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
eenvoudige verhalen en korte informatieve teksten begrijpt (7)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
werkwoorden en vervoegingen op een correcte manier gebruikt (8)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
geschreven tekst als communicatiemiddel kan gebruiken (9)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
woorden kan onthouden en kan gebruiken in spel (10)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Appendix B: Component matrices

Appendix B contains the seven structure component matrices associated with the principal-component analyses performed during the data reduction. These are the component matrices for 1) literacy skills, 2) formal use of digital literacy material, 3) digital educational literacy activities, 4) digital leisure literacy activities, 5) parent's expectations about their children's literacy learning, 6) parents' attitudes towards their children's literacy learning, and 7) parents' modelling behaviour towards literacy.

Structure matrix 1

Component matrix of literacy skills

Test scores	Component	
	Early literacy skills	Vocabulary skills
Grapheme-phoneme knowledge	,842	
Segmentation-task	,789	
Deletion-task	,768	-,361
Standardized vocabulary	,521	,837

Structure matrix 2

Component matrix of formal use of digital devices

Question	Component
	Formal use of digital literacy material
Formal use of the computer	0.584
Formal use of the smartphone	0.584

Structure matrix 3

Component matrix of digital performed literacy activities: digital educational literacy activities

Question	Component
	Digital educational literacy activities
Digital self-reading activity	.556
Digital writing activity	.845
Digital letter naming	.772

Structure matrix 4

Component matrix of digital performed literacy activities: digital leisure literacy activities

Question	Component
	Digital leisure literacy activities
Reading aloud using e-books	.474
Looking at digital picture books	.682
Digital rhyming or singing	.747
Playing digital language games	.646

Structure matrix 5

Component matrix of parents' expectations about their children's literacy learning

Statement	Component
	Parents' expectations about their children's literacy learning
I expect my child to be able to read words with different spelling patterns correctly by the end of the first grade (e.g., flat or poster)	,845
I expect my child to be able to read multisyllabic words correctly at the end of first grade (e.g., bloempot, blokken, ballon)	,781
I expect my child to be able to read short words in which the phonemes are equal to the graphemes correctly and fluently at the end of first grade (e.g., krant, stronk, plant)	,780
I expect my child at the end of first grade to be able to read a simple short text fluently with the correct intonation	,716
I expect my child to understand simple stories and short informative texts at the end of first grade	,696
I expect my child to be able to write short words in which the phonemes are equal to the graphemes independently at the end of first grade (e.g., krant, stronk, plant)	,684
I expect my child to use verbs and conjugations correctly at the end of first grade	,585
I expect my child to be able to use written text as a means of communication at the end of first grade	,561
I expect my child to be able to remember words at the end of first grade and to use them in play	,487
I expect my child to be able to name and write all letters at the end of first grade	,310

Structure matrix 6

Component matrix of parents' attitudes towards their children's literacy learning

	Component	
	Parents' attitudes towards their children's literacy learning	
Parents/carers are required to do activities at home to contribute to the development of their child's reading and language skills.	,642	
I need to pay extra attention to my child's reading and language skills outside of school.	,763	
Parents/carers are jointly responsible for the development of their child's reading and language skills.	,801	

Structure matrix 7

Component matrix of parents' modelling behaviour towards literacy

Question	Component	
	Parents' modelling behaviour in relation to literacy for education	Parents' modelling behaviour in relation to literacy for leisure
Frequency of using digital resources for purposes other than entertainment	,758	
Frequency of reading digital newspapers	,571	-,548
Frequency of reading digital magazines	,329	,654
Frequency of reading e-books	,366	,598

Appendix C: Assumption checking

Assumption checking for correlation test

Before the correlation test could be carried out with all 10 variables, the corresponding assumptions were first checked. First, the normality assumption was checked using the Shapiro Wilk test, and the absence of outliers was checked using the boxplot and the Q-Q plot. Linear relationships were checked via a scatterplot, and homoscedasticity was checked by means of a scatterplot of the residuals and the Levene's test. All assumptions could be met except the normality assumption. The variables formal use of digital literacy material ($D(48) = .466, p < .001$), parents' expectations about their children's literacy learning ($D(48) = .873, p < .001$), parents attitudes to their children's literacy learning, $D(48) = .858, p < .001$), parents' modelling behaviour in relation to literacy for education ($D(48) = .927, p = .005$) and parents' modelling behaviour in relation to literacy for leisure ($D(48) = .746, p < .001$) were all not normally distributed. Therefore, instead of the presumed Pearson correlation test, the non-parametric variant was carried out: the (two-sided) Spearman rank-order correlation test.

Assumption checking for multiple regression analyses and mediation analyses

Before the multiple regression analyses and the mediation analyses were conducted, the independent variables (early literacy and vocabulary skills) were checked for possible multicollinearity. In addition, the VIF was found to be sufficient (< 1) and a plot indicated homoscedasticity. The Durbin-Watson test indicated that the residuals were uncorrelated and a histogram of the standardised residual plots showed a normal distribution. Finally, a linearity plot showed that there was a linear relationship between the independent and the eight dependent variables.