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Online Research and Comprehension Performance Profiles Among Sixth-Grade Students, Including Those with Reading Difficulties and/or Attention and Executive Function Difficulties

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ABSTRACT

This study identified online research and comprehension (ORC) performance profiles of 436 sixth-grade students (206 girls) aged 12–13 years. We included learner groups with different learning-related difficulties and explored how students' reading habits were represented in various performance profiles. First, students' ORC performance was examined with a validated web-based assessment measuring their skills in locating, evaluating, synthesizing, and communicating information. Second, reading fluency and teacher-rated attention and executive function (EF) difficulty scores were used to form learner groups: (1) students with reading difficulties, (2) students with attention and EF difficulties, (3) students with comorbid difficulties in reading as well as attention and EF, and (4) students without these identified difficulties. Third, students' reading habits were assessed with a questionnaire asking how often they read different kinds of texts. Seven ORC performance profiles were identified. Most of the profiles related to the students' ORC performance level, except the profile of the average performers with low questioning credibility scores. Students with learning-related difficulties were more likely to belong to the lower performance profiles, and all top performers were students without identified difficulties. However, 25.7% of students with reading difficulties and 16.2% of students with attention and EF difficulties performed at average or good levels of ORC. Finally, the frequency of reading longer texts, such as books and blog posts, was more clearly associated with students' online reading performance than reading shorter texts, such as comics and online forum posts.

In the last two decades, remarkable progress has been made in understanding how readers learn from online information (Brand-Gruwel et al., 2009; Cho and Afflerbach, 2015; Coiro and Dobler, 2007; Leu et al., 2019). Research has illuminated the core skills of successful online reading but has also found substantial individual differences in these skills (Cho et al., 2018; Coiro et al., 2015; Fraillon et al., 2020; Leu et al., 2015; van Deursen, and van Diepen, 2013). To better understand the role of individual differences in acts of reading, we need to learn more about the nature and origin of these differences (Afflerbach, 2016). However, previous research has been limited in at least three respects.

First, researchers have examined how inter-individual differences, such as offline reading skills and prior knowledge, are associated with students' online reading performance (e.g., Coiro, 2011; Kanniainen et al.,

2019; Salmerón et al., 2018) but have rarely employed a person-centered approach that moves beyond the effects of single variables and characteristics to study multifaceted individual differences (Cromley, 2020). Second, most of the studies have focused on regular learners (Anmarkrud et al., 2018), except for a few studies concerning individuals with reading difficulties (Andresen et al., 2019a; Andresen et al., 2019b; Castek et al., 2011; Henry et al., 2012) or difficulties in attention and executive function (EF) (Caccia et al., 2019; Kanniainen et al., 2021). Moreover, to our knowledge, no previous studies have addressed learners' online research and comprehension (ORC) performance among individuals with comorbid—i.e., overlapping and co-occurring—difficulties in reading as well as attention and EF. Third, even though students seem to have different preferences for certain reading media and purposes (e.g., Jang et al., 2021; McKenna et al., 2012), the role of their reading habits has not been evaluated in association with their ORC performance.

Based on these three considerations, the present study aims to increase our understanding of the inter-individual differences in students' online reading performance by employing a person-centered approach—more precisely, latent profile analysis. In particular, we investigated how students with reading difficulties, students with teacher-rated attention and EF difficulties, students with comorbid difficulties in reading and attention and EF, and students without these difficulties are represented in different ORC performance profiles. To better understand learners' ORC performance, we also included students' reading habits, such as the frequency of reading books and online news, as an additional layer of investigation.

Online Research and Comprehension

In the present study, we build on the online research and comprehension (ORC) framework (Kinzer and Leu, 2017; Leu et al., 2019). This framework defines ORC as a self-directed, cyclical process that positions learners to construct texts and knowledge in web-based reading environments. During text and knowledge construction, learners employ the following component skills: (1) identifying questions, (2) locating information, (3) evaluating information, (4) synthesizing information, and (5) communicating information (Leu et al., 2019).

Learners begin by *identifying* task-relevant questions to direct their reading process and knowledge construction (Leu et al., 2019). In a school context, questions on a particular topic can be given by a teacher or generated together with a teacher and students (Kingsley and Tancock, 2014). *Locating* information by typing adequate search queries into a search engine and selecting relevant webpages from search results is another component of the process (Cho and Afflerbach, 2015; Coiro and Dobler, 2007). Successful online readers are able to adapt their search behavior according to the task features (Naumann, 2015) and, for instance, may use more time to formulate their search queries when the task demands increase (Walhout et al., 2017). Recently, eye-tracking research has successfully been applied to reveal learners' behaviors when using search engines to locate relevant information (for a review, see Lewandowski and Kammerer, 2020). For example, elementary-school students pay attention to titles, snippet texts, and even URL addresses of the search results, although some of the students may predominantly base their text selection only on the titles (Hautala et al., 2018).

Beyond the evaluation of the search results, learners should also critically *evaluate* the information processed during their knowledge construction (Leu et al., 2019). In terms of the credibility of information, skilled readers evaluate different content- and source-based features, such as the relevance and accuracy of the content, authors' expertise and intentions, and information type and date (Braasch et al., 2012, 2013; Macedo-Rouet et al., 2019; Stadtler and Bromme, 2014). Ideally, the evaluation of the content- and source-based features is reciprocal (Stadtler and Bromme, 2014), but many middle- and secondary-school students tend to rely on content features, such as readability and topical relevance, in their evaluations (Coiro et al., 2015; Macedo-Rouet et al., 2019). Even though adolescent readers may be able to name the authors behind the information (Coiro et al., 2015; Macedo-Rouet et al., 2013), they do not necessarily spontaneously evaluate the authors' competence or experience (Macedo-Rouet et al., 2019). In particular, when the information is, in a certain way, unreliable (e.g., published under commercial interests or in suspicious media), questioning the credibility of information seems to be challenging for readers (Kiili et al., 2018; Perez et al., 2018).

Furthermore, younger readers very rarely use their credibility evaluations when *synthesizing* information (Hämäläinen et al., 2020), although comparing and contrasting different viewpoints is essential for successful synthesis from multiple online texts (e.g., Cho and Afflerbach, 2015; Rouet, 2006). Although learners are expected to gather main ideas from multiple online texts (for reviews, see Barzilai et al., 2018; Primor and Katzir, 2018), both elementary-school students (Kiili et al., 2020) and secondary-school students (van Strien et al., 2014) may still base their knowledge construction on only one information resource or fail to fully integrate the contents from different online resources. However, specific instructions and prompts may help students in information integration (Barzilai et al., 2018). Especially, when the online information is controversial, students need practice in presenting well-justified arguments (Driver et al., 2000). In order to *communicate* information, learners are expected to have good argumentation skills to be able to address their justified, source-based position to a certain audience (Leu et al., 2019).

Reading Difficulties and Difficulties in Attention and Executive Function

Difficulties in reading and attention and EF are the two most common areas hindering learning (American Psychiatric Association, 2018) and, also, occur comorbidly—i.e., they overlap and co-occur in the same individual (Moll et al., 2020; Willcutt and Pennington, 2000). For instance, learners with difficulties in reading seem to have difficulties in attention and EF in 15–40% of cases (Shaywitz et al., 1995; Willcutt and Pennington, 2000; Willcutt et al., 2005). The prevalence of reading difficulties and difficulties in attention and EF suggests the need for a better understanding of how these learning-related problems are associated with student performance when reading to learn from online information.

Students with Reading Difficulties

Reading difficulties are defined as failure in accurate and fluent letter-sound decoding and word recognition skills (Gough and Tunmer, 1986; Lyon et al., 2003; Vellutino et al., 2004). The low accuracy and automaticity of decoding and word recognition are manifested in reduced reading fluency (Fuchs et al., 2001; LaBerge and Samuels, 1974; Perfetti and Stafura, 2014). At a higher level of reading, learners are expected to integrate word meanings and to recognize wider topics in order to construct a deeper understanding of the text (Kintsch, 1998). If learners' lower-level reading skills, such as decoding, word recognition, and reading fluency, are not sufficient, the problems may affect higher-level comprehension processes (Hulme et al., 2015; LaBerge and Samuels, 1974; Perfetti and Stafura, 2014).

Recent research on students' ORC skills is in line with this: difficulties in lower-level reading skills seem to reduce the level of online reading comprehension. For instance, Kanniainen et al. (2019) found that students' reading fluency level, measured using a factor consisting of word recognition and decoding of pseudowords, was associated with elementary-school students' online reading performance. Additionally, students' written spelling skills were associated with their ORC performance, and written spelling level also independently contributed to students' locating, synthesizing, and communicating skills (Kanniainen et al., 2019). Further, Macedo-Rouet et al. (2013) found that elementary-school students' word recognition skills were associated with how well students justified their information source selection, which seems to be a prerequisite for successful evaluation of information.

However, the role of lower-level reading skills seems to diminish among secondary-school students. For example, Salmerón et al. (2018) noticed that a word recognition task was associated with students' search selections on a search engine result page but not with their actual navigation processes and reading of online texts. Also, Hahnel et al. (2018) found that a word recognition task did not have a unique predictive power over reading comprehension on students' performance in the evaluation of information. Regardless of the grade level, it seems that reading comprehension is the strongest predictor of students' ORC performance and the components involved in successful performance (e.g., Coiro, 2011; Kanniainen et al., 2019; Salmerón et al., 2018).

Beyond this variable-centered view, there are only a few studies that have examined ORC among students with reading difficulties, and those were small case studies of three to four students (Castek et al., 2011; Henry et al., 2012). These studies have mainly concentrated on supportive technological and visual elements. For instance, web-based reading environments can provide comprehension support for learners with reading difficulties by providing non-textual elements, such as pictures and videos, making learners less dependent on their reading skills (Castek et al., 2011; Henry et al., 2012). However, based on a somewhat larger sample comparing 22 students with reading difficulties and 22 students without reading difficulties, it was shown that students with reading difficulties seem not to use these kinds of elements more often than students without reading difficulties (Andresen et al., 2019a).

Along with technological and visual elements, we know little about how students with reading difficulties are actually able to locate, evaluate, synthesize, and communicate information and what kinds of ORC performance profiles they represent. It is noteworthy that some students may even be able to use some compensatory mechanisms to cope with their reading difficulties online. For example, Andresen et al. (2019b) found that in a group of four dyslexic students, one student with serious reading difficulties managed to increase his or her knowledge substantially by compensating for reading deficiencies by dedicating time to the task.

Students with Attention and Executive Function Difficulties

Difficulties in students' attentional processes and EF are defined as failure to focus, sustain, and shift attention (Mirsky et al., 1999), as well as failure to inhibit, for example, external distractions and update working memory contents (Friedman and Miyake, 2017; Miyake et al., 2000). Further, at a higher level of EF, learners may face difficulties when expected to be able to plan and monitor their actions (for reviews, see Diamond, 2013; Friedman and Miyake, 2017). Thus, difficulties in attentional processes (e.g., Cain and Bignell, 2014; Miller et al., 2013) and EF (for reviews, see Butterfuss and Kendeou, 2018; Follmer, 2018) may interfere with learners' reading comprehension by impeding their ability to build mental representations.

Learners' ability to build mental representations may be even more crucial online. For example, Caccia

et al. (2019) found that both students' self-reported and measured attention and EF difficulties—more specifically concentration difficulties—were associated with their online reading performance. Further, in a study by Kanniainen et al. (2021), teacher-reported difficulties in students' attentional processes, execution of actions, and inhibition were associated with their ORC performance in a simulated Internet environment. In web-based reading environments, students are required to go beyond processing a single linear text and shift their attention between multiple texts and different ORC processes. Thus, web-based reading environments seem to set additional requirements for learners to monitor and regulate their actions (Cho et al., 2017; Coiro and Dobler, 2007).

Students with Comorbid Difficulties

The above-defined reading difficulties and difficulties in attention and EF can show comorbidity among the same individuals (e.g., Moll et al., 2020; Willcutt and Pennington, 2000). Learners with comorbid difficulties often face more academic difficulties than learners with either deficiency alone (e.g., Willcutt et al., 2007). As shown above, students with low literacy skills or difficulties in attention and EF may struggle online. Although no previous studies have addressed ORC performance among learners with comorbid difficulties, it is highly likely that reading in complex web-based environments is cognitively overloading, especially for learners with both reading difficulties and difficulties in attention and EF. Deep-level text processing is necessary for reading to learn from multiple texts, as readers are required to integrate information and formulate conclusions across these texts (Dinsmore and Alexander, 2016; List and Alexander, 2017). Particularly for students with comorbid difficulties, this kind of deep-level text processing may take a great deal of time and effort and require instructional support.

Students' Reading Habits

To build a deep-level, coherent understanding of a text, readers need to elaborate main ideas in a text by integrating those ideas with their prior knowledge (Kintsch, 1998). However, younger readers may not necessarily be skilled enough to draw on their prior knowledge to establish coherence, especially if they also have difficulties related to comprehension (e.g., Brandão and Oakhill, 2005; Cain et al., 2001). Reading comprehension and knowledge seem to have a reciprocal relationship in which knowledge supports comprehension but comprehension also seems to support the use of knowledge as well as the building of new knowledge (for a review, see Cervetti and Wright, 2020). Thus, knowledge can also be regarded as a product of reading comprehension beyond its role as a predictor. Students who read in their free time seem to develop not only stronger reading fluency and comprehension skills but also a larger knowledge base than students who read less (for reviews, see Mol and Bus, 2011; Schiefele et al., 2012). Hence, it is important to include learners' reading habits in the examination of their ORC performance.

Book-reading seems to be the strongest predictor of successful reading comprehension, whereas reading other materials, such as newspapers, magazines, and comics, has only minor or no effects (Pfost et al., 2013; Spear-Swerling et al., 2010; Torppa et al., 2020). In regard to learners' digital reading habits, it seems that digital text consumption may even have negative associations with comprehension. For example, Pfost et al. (2013) and Torppa et al. (2020) found that the reading frequency of digital texts, such as emails, instant messages, and forum posts, was negatively associated with students' comprehension. However, learners' digital reading habits should not be seen narrowly, only from the perspective of social online engagement. Namely, Lupo et al. (2017) found that students' positive attitudes toward reading academic digital texts, such as ebooks and online news for a class, correlated positively with reading comprehension, but attitudes toward free time reading of digital texts, such as emails and instant messages, did not.

Further, Naumann (2015) found a negative relation between social online engagement and students' navigation behavior—i.e., the number of students' visits and revisits to task-relevant pages, but a positive relation between students' navigation and information engagement, such as reading online news and searching for information on the Internet. Though most students are used to utilizing digital media, there are students who prefer more print media (Jang et al., 2021; McKenna et al., 2012). However, more research is needed, particularly an examination of how students' reading habits are associated with their performance when reading to learn from online information.

The Present Study

We set out to examine learners' various profiles of online research and comprehension performance by using a person-centered approach, more specifically latent profile analysis. By including different learner groups, this study aims to increase our understanding of how students' reading difficulties and/or teacher-rated difficulties in attention and EF are associated with their ORC performance. Reading habits may also play an important role when elementary-school students read in web-based environments; thus, we also examine learners' reading habits in relation to their ORC performance. Specifically, we sought to answer the following three research questions:

1. What kinds of online research and comprehension performance profiles can be identified among sixth-grade students?

2. How are different learner groups (students with reading difficulties, students with attention and EF difficulties, students with comorbid difficulties in reading and attention and EF, and students without these identified difficulties) represented in various online research and comprehension performance profiles?
3. How do students' reading habits vary across different online research and comprehension performance profiles?

In this study, we used latent profile analysis, which is, like other person-centered approaches, typically conducted in an exploratory manner (Hoijtink, 2001; Meyer and Morin, 2016). Thus, we do not give an a priori hypothesis for the number or nature of the online research and comprehension performance profiles. Further, we do not give an a priori hypothesis for how the different learner groups or students' reading habits are represented in these data-driven profiles.

Method

Sample and Procedure

The participants were 436 students (*M* age = 12.34, *SD* = 0.33; 47% females) attending the sixth grade of basic elementary education in Finland during the years 2014–2016. Based on the students' reading fluency and teacher-rated attention and EF difficulty scores, they were divided into learner groups: (1) students with reading difficulties (n = 39), (2) students with attention and EF difficulties (n = 37), (3) students with comorbid difficulties in reading as well as attention and EF (n = 17), and (4) students without these identified difficulties (n = 343). The identification criteria are presented later in the Learner Groups section.

Of these 436 students, 426 were recruited from 24 intact classes representing eight Finnish elementary schools, both suburban and rural. We contacted (by email or phone) the school principals, who then forwarded our recruitment request to classroom teachers. Thirteen students were excluded from the analysis because of missing data essential for assigning students to learner groups. Based on the prevalence of the reading and attention and EF difficulties (American Psychiatric Association, 2018), students with these difficulties were underrepresented among the 426 students. Thus, an additional 23 students with reading difficulties and/or teacher-rated difficulties in attention and EF were recruited by contacting special education teachers and psychologists because we were especially interested in how students with these kinds of difficulties performed online. These students were recruited from another seven elementary schools representing basic elementary education in Finland. The population of the first eight schools was similar to that of the latter seven. The special education teachers and psychologists contacted the students' guardians to ask for permission for the students to participate.

All 436 students participated voluntarily and were taught in mainstream classrooms. Most special educational services are provided in schools for free and a formal diagnosis is not needed for students to receive these services (Björn et al., 2016). The most common form of special educational services is part-time special education given by a special education teacher (Pulkkinen et al., 2020), in which students are studying in mainstream classrooms and receive support, for example, for reading and spelling a few hours per week from a special education teacher (Holopainen et al., 2018). This support is often put into practice in a small group (3–4 students at the same time) or individually, if the difficulties are more severe or if the student has multiple learning-related difficulties at the same time (Holopainen et al., 2018). All participating 436 students followed the Finnish National Curriculum (The Finnish National Board of Education, 2004). In this version of the curriculum, the ORC component skills mainly appeared in the subject of Finnish language and literature. For instance, the Finnish language and literature section of the curriculum identifies the importance of locating information, critically evaluating it, and using multiple information resources in knowledge construction or synthesis.

The Ethical Committee of the University of Jyväskylä gave their approval, and the guardians signed a written consent form for their children's participation. Most parents of participating students had at least an upper-secondary education (93% of mothers and 88% of fathers). This is close to the Finnish national average, which is 88.3% of people aged 25–54 with at least an upper-secondary education (Eurostat, 2013). Our sample was also relatively homogeneous in regard to students' access to the Internet and email. Specifically, 97% of students had internet access at home, and 90% of students had an email address.

The data were collected at schools during three regular 45-minute class periods. In the first two sessions, students completed paper-and-pencil tests and a questionnaire concerning their reading habits. In the last session, the students completed an online research and comprehension task with laptops at their own pace. If needed, students were allowed to use their 15-minute recess to complete the task.

Measures

Online Research and Comprehension

We measured students' online research and comprehension skills using a Finnish online research and comprehension assessment (Kiili et al., 2018). This assessment was modified from a previous one called ORCA, which was

developed in the United States with good levels of validity and reliability (Leu et al., 2015). The assessment simulated an internet environment and consisted of tasks that measured four ORC components: (1) locating information, (2) evaluating information, (3) synthesizing information, and (4) communicating information. Neither the original assessment, ORCA, nor the Finnish assessment included a task measuring the component of identifying important questions. Thus, the results should be considered as representing directed inquiry, as opposed to independent inquiry.

The assessment began with an email containing a common task assignment, which was sent by a fictitious school principal. The principal instructed students to explore the health effects of energy drinks and to write a justified recommendation on whether or not an energy drink vending machine should be purchased for the school. In the assessment, students were prompted through the tasks by two avatar students. The avatars prompted students via a simulated social networking site and a chat message window. Students were asked to examine four different online resources (two news pages [OR1, OR4], an academic online resource [OR2], and a commercial online resource [OR3]) during the task to form their recommendation. Next, we will describe the subtasks by the component skills that they measured.

In the *locating* component, students formulated a search query in a search engine to locate two of the online resources (OR2, OR4). The avatar prompted students by giving the following instructions: "My friend gave me a tip about a webpage of a certain university presenting information related to energy drinks. Please find this webpage [OR2]"; "I have heard my friends talking about the health effects of energy drinks on teeth. Next, please find a webpage about these effects [OR4]." After the search query, students received the search engine result page and were asked to distinguish the relevant online resource from the irrelevant ones. If a student failed in this task, the avatar gave the right link to the correct online resource. Thus, students were still able to read the correct resource and receive credits in the next parts of the task. In the *evaluation* component, students evaluated two online resources (OR2, OR3) by answering three questions presented by the avatar: (1) "Who is the author of the webpage?"; (2) "Is the author an expert on health issues related to energy drinks? Why do you think so?"; (3) "Is the information provided on the webpage reliable? Why do you think so?"

In the *synthesizing* component, students took notes from all four online resources with a notetaking tool. The avatar prompted students to use their own words. After reading all four resources, students wrote a summary of what they had learned about the health effects of energy drinks by synthesizing information across the resources. The notes were available when students wrote their summaries. In the *communication* component, students responded to the principal's email by composing a justified recommendation regarding whether or not the principal should purchase the energy drink vending machine for the school.

Figure 1 presents a flowchart of the ORC assessment and scoring criteria for students' performance in the aforementioned components. Screenshots of the stimulus materials are also presented in Figure 1, and descriptive statistics are presented in Table 1. The Kappa values for inter-rater reliability were 1.00 for locating and ranged from .95 to .98 for evaluating, from .78 to 1.00 for synthesizing, and from .72 to .94 for communicating. McDonald's omega reliability coefficient for the total score was .88.

Validation of the factor structure of the Finnish assessment was performed via confirmatory factor analysis. The results reflected the original ORC model (Kiili et al., 2018). The standardized factor scores for each component skill, based on previous work (Kiili et al., 2018), were used in the analyses, and we present the factor structure in the data analysis section.

Reading Fluency

We measured students' reading fluency with three tests: a time-limited word recognition test (Lindeman, 1998), a time-limited word chain test (Holopainen et al., 2004), and an oral pseudoword-reading test (Eklund et al., 2015). Descriptive statistics for reading fluency tests are presented in Table 1. McDonald's omega reliability coefficient for these three tests was .79.

In the group-administered word recognition test (Lindeman, 1998), we instructed students to identify and connect the correct picture–word pairs by drawing a line between a word and a picture. This test included 80 items, and each item consisted of a picture and four alternative written words. The score was the number of correctly connected pairs within the time limit of two minutes.

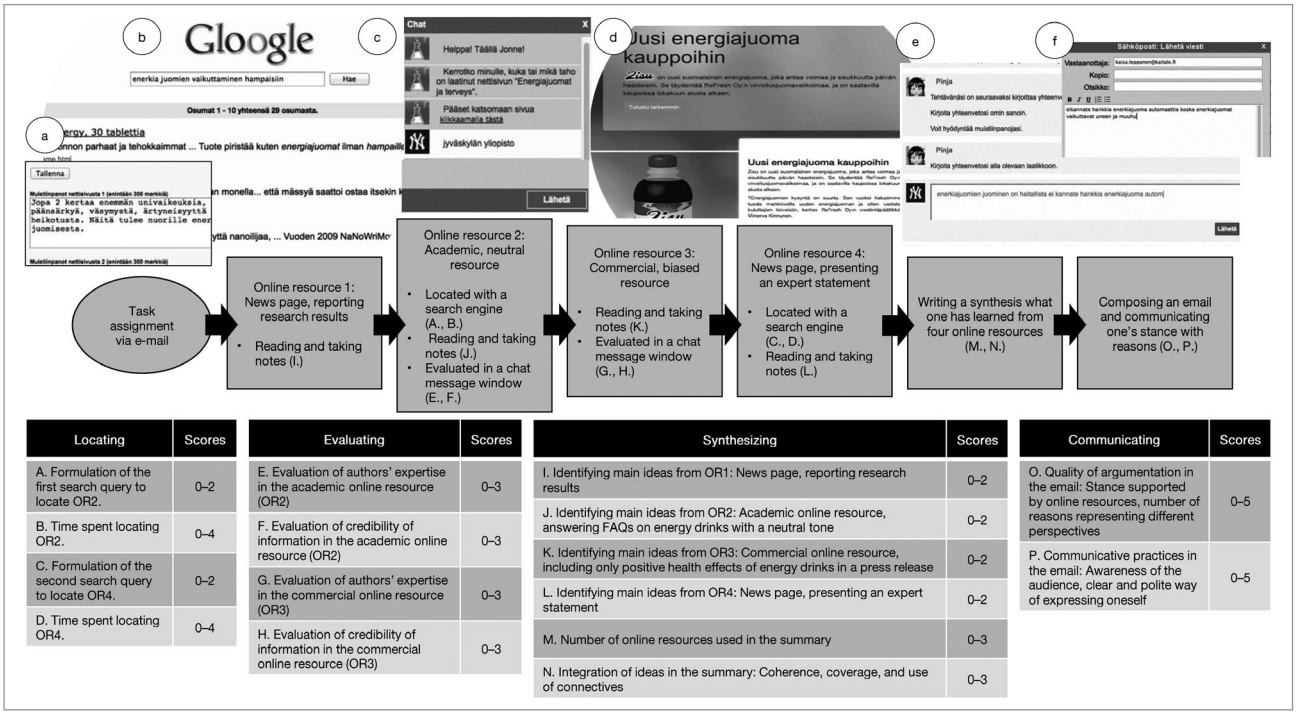
In the group-administered word chain test (Holopainen et al., 2004), we instructed the students to draw a line at the word boundaries. This test consisted of 25 word chains of four words written without spaces between them. The score was the number of correctly separated words within the 90-second time limit.

In the individually administered oral pseudoword-reading test (Eklund et al., 2015), we instructed students to read aloud as quickly and accurately as possible a short passage of 38 pseudowords (277 letters). Students' reading performance was audio-recorded for scoring, and the score was the number of correctly read pseudowords divided by the time, in seconds, spent on reading.

Teacher-Rated Attention and Executive Function Difficulties

To assess students' attention and EF difficulties, we used the Attention and Executive Function Rating Inventory

FIGURE 1
Screenshots and a Flowchart of the Online Research and Comprehension Assessment, Together with the Scoring Criteria for Students' Performance



Locating	Scores
A. Formulation of the first search query to locate OR2.	0–2
B. Time spent locating OR2.	0–4
C. Formulation of the second search query to locate OR4.	0–2
D. Time spent locating OR4.	0–4

Evaluating	Scores
E. Evaluation of authors' expertise in the academic online resource (OR2)	0–3
F. Evaluation of credibility of information in the academic online resource (OR2)	0–3
G. Evaluation of authors' expertise in the commercial online resource (OR3)	0–3
H. Evaluation of credibility of information in the commercial online resource (OR3)	0–3

Synthesizing	Scores
I. Identifying main ideas from OR1: News page, reporting research results	0–2
J. Identifying main ideas from OR2: Academic online resource, answering FAQs on energy drinks with a neutral tone	0–2
K. Identifying main ideas from OR3: Commercial online resource, including only positive health effects of energy drinks in a press release	0–2
L. Identifying main ideas from OR4: News page, presenting an expert statement	0–2
M. Number of online resources used in the summary	0–3
N. Integration of ideas in the summary: Coherence, coverage, and use of connectives	0–3

Communicating	Scores
O. Quality of argumentation in the email: Stance supported by online resources, number of reasons representing different perspectives	0–5
P. Communicative practices in the email: Awareness of the audience, clear and polite way of expressing oneself	0–5

Notes. (a) The notetaking tool, (b) the search engine, (c) the chat message window, (d) the commercial online resource (OR3) as an example of online resources, (e) the simulated social networking site, and (f) the mailbox. OR1 = online resource 1; OR2 = online resource 2; OR3 = online resource 3; OR4 = online resource 4. More detailed scoring criteria published by Kiili et al. (2018) are available upon request from the first author. One of the observed variables of locating (A.) did not load on the locating factor, and thus, was omitted from the analyses in the validation of the assessment (see Kiili et al., 2018).

(ATTEX; Klenberg et al., 2010b). With the inventory, teachers ($N = 24$) evaluated all their student's difficulties in attention and EF in school-related situations. Teachers were asked to rate students' difficulties with 55 items under ten scales. Each item had a three-point response scale (0 = not a problem; 1 = sometimes a problem; 2 = often a problem). An example item from each scale and the descriptive statistics are presented in Table 1. The ATTEX inventory is available in English as an appendix in Klenberg et al. (2010b). The ATTEX inventory has shown good criterion validity ($r = .76–.95$; Klenberg et al., 2010b) with the ADHD Rating Scale–IV: School Version (DuPaul et al., 1998). In the present study, McDonald's omega reliability coefficient was .94.

Learner Groups

As mentioned earlier, students do not need a formal diagnosis to receive special educational services in Finnish educational system (Björn et al., 2016). Thus, in the school context teachers and parents together with students assess the need for support by themselves (Holopainen et al., 2018). In the research context, researcher measures, such as composite scores and rating scales with different kinds of cut-offs are frequently used. For instance, the lowest 10th percentile on a reading composite score, including accuracy and fluency measures, is often considered as a cut-off point for dyslexia among Finnish children (Jyväskylä Longitudinal Study of Dyslexia [JLD]; see Eklund et al., 2015; Torppa et al., 2010), but also in other languages as well (for a review, see Snowling and Melby-Lervåg, 2016; Pennington et al., 2012).

Hence, students' reading fluency was measured by a single reading fluency factor based on performance in the three reading tests described above (under Reading Fluency). The reading fluency factor was obtained using principal axis factoring (PROMAX rotation; an eigenvalue of 1 as a criterion). Students whose reading fluency score was below the 10th percentile were included in the group of students with reading difficulties ($n = 39$; 33% females). The 10th percentile cut-off value was formed based on the original group of 426 participants, and the 23 supplementary participants were assigned to the groups based on this cut-off. For the supplementary participants, we calculated the factor scores by adding one student at a time to the main data, and then running the factor analysis to get the factor score for each of these students. This was done as a preliminary step of the analysis

TABLE 1
Descriptive Statistics of Online Research and Comprehension, Reading Fluency, and Teacher-Rated Attention and Executive Function Difficulties

Online Research and Comprehension	*M*	*SD*	*Min.*	*Max.*
1) Locating Information (max. 10 points)	4.73	2.14	0.00	10.00
2) Evaluating Information (max. 12 points)	5.76	3.03	0.00	12.00
3) Synthesizing Information (max. 14 points)	6.83	2.90	0.00	14.00
4) Communicating Information (max. 10 points)	4.31	2.41	0.00	10.00
Reading Fluency	***M***	***SD***	***Min.***	***Max.***
1) Word Recognition Test (max. 80 points)	48.42	9.34	21.00	80.00
2) Word Chain Test (max. 100 points)	42.81	14.50	11.00	85.00
3) Pseudoword-Reading Test (correctly read words/seconds)	0.70	0.21	0.19	1.36
Teacher-Rated Attention and Executive Function Difficulties	***M***	***SD***	***Min.***	***Max.***
1) Distractibility (q1–4; max. 8 points): 'Activities are interrupted by even the smallest external distracter' (q1)	1.08	1.66	0.00	8.00
2) Impulsivity (q5–q13; max. 18 points): 'Is clearly impatient' (q5)	1.77	3.50	0.00	18.00
3) Motor Hyperactivity (q14–q20; max. 14 points): 'Constantly needs manual activities' (q14)	0.80	1.99	0.00	14.00
4) Directing Attention (q21–q25; max. 10 points): 'Has difficulties focusing attention on instructions given to the whole group' (q21)	1.33	2.08	0.00	10.00
5) Sustaining Attention (q26–q31; max. 12 points): 'Has difficulties completing tasks' (q26)	1.16	2.22	0.00	12.00
6) Shifting Attention (q32–q35; max. 8 points): 'Has difficulties noting two things at the same time' (q32)	0.73	1.58	0.00	8.00
7) Initiative (q36–q40; max. 10 points): 'Is not able to start on tasks without extra supervision' (q36)	1.14	2.02	0.00	10.00
8) Planning (q41–q44; max. 8 points): 'Starts working on tasks without planning' (q41)	0.74	1.56	0.00	8.00
9) Execution of Action (q45–q52; max. 16 points): 'Needs additional. individual supervision to accomplish tasks' (q45)	1.60	2.60	0.00	14.00
10) Evaluation (q53–q55; max. 6 points): 'Is not able to foresee consequences of own actions' (q53)	0.52	1.13	0.00	6.00

to prevent overrepresentation of this supplementary sample in the factor score estimation.

Next, we calculated the scores for students' teacher-rated attention and EF difficulties. To decide whether students belonged to the group of students with attention and EF difficulties (n = 37; 19% females), we used the cut-off scores from the ATTEX manual (Klenberg et al., 2010a): 36 points for boys and 20 points for girls. If a student had difficulties in both areas, they belonged to the group of students with comorbid difficulties in reading and attention and EF (n = 17; 24% females). The remaining students belonged to the group of learners without identified difficulties (n = 343; 53% females).

Reading Habits

We measured students' reading habits via a self-report questionnaire including eight items. The first four items measured print reading frequency: students' frequency of reading (a) books (e.g., novels, nonfiction), (b) newspapers (an example of the Finnish newspaper), (c) magazines (examples of Finnish magazines targeted to adolescents), and (d) comics. The last four items measured digital reading frequency: students' frequency of reading (a) ebooks, (b) online newspapers (examples of Finnish online newspapers), (c) websites on various topics (e.g., interests, hobbies, sports), (d) blog posts, and (e) forums (e.g., discussions of games, artists, hobbies). Ratings were given on a 5-point Likert scale [1 = hardly ever; 2 = rarely (1–2 times per month); 3 = 1–2 times per week; 4 = almost every day; 5 = every day]. McDonald's omega reliability coefficient was .62. Presumably, the somewhat low omega was due to the omega's assumption of unidimensionality (see, e.g., Savalei et al., 2019). Students seem to prefer different kinds of media and purposes (see also Jang et al., 2021); thus, we used these variables at the item level. Descriptive statistics for reading habits are presented in Table 2.

TABLE 2
Descriptive Statistics of Reading Habits

Print Reading Habits	*M*	*SD*
1) Books	2.87	1.20
2) Newspapers	1.97	1.01
3) Magazines	1.82	0.90
4) Comics	2.76	1.30
Digital Reading Habits	***M***	***SD***
1) Ebooks	1.08	0.39
2) Online Newspapers	2.10	1.15
3) Websites	2.45	0.97
4) Blog Posts	1.57	0.91
5) Forums	1.76	0.99

Note. Observed range in all variables 1–5.

Statistical Analyses

The aforementioned descriptive and reliability analyses were conducted with IBM SPSS Statistics 26, and analyses related to latent profiling were conducted using Mplus version 8 (Muthén and Muthén, 1998–2017). Before we explain latent profiling in more detail, it needs to be specified that we used saved factor scores of online research and comprehension from our previous study (Kiili et al., 2018). In this previous study, we used confirmatory factor analysis (CFA) to validate the ORC assessment and the theory-based structure of the ORC model with the same sample of 426 sixth graders. We used the weighted least square mean and variance adjusted (WLSMV) estimator, since the ORC variables were ordered categorically (Li, 2016). To ensure acceptable model fit, we used the following cutoff criteria: $\chi 2$-test (ns, $p > .05$), root mean square error of approximation (RMSEA) < 0.06, and Tucker–Lewis index (TLI) and comparative fit index (CFI) ≥ 0.95 (Hu and Bentler, 1999). The comparison of nested ORC measurement models was implemented in Mplus with a DIFFTEST option. We summarize the results of this comparison in Appendix A.

The validation of the ORC model confirmed the following basic structure: (1) locate, (2) evaluate, (3) synthesize, and (4) communicate information. Further, this model suggested that evaluation of information be divided into two factors: (2a) confirming the credibility of information in more credible texts and (2b) questioning the credibility of information in less credible texts. Synthesizing was also divided into two factors: (3a) identifying main ideas from a single online text and (3b) synthesizing information across multiple online texts. Altogether, the final six-factor model fit the data very well [$\chi^2(75) = 83.57$, $p = .233$; RMSEA = .02; CFI = 1.00; TLI = 1.00], and the correlations between these six component skills varied from .29 to .73 (Kiili et al., 2018). McDonald's omega reliability coefficient (1) for locating was .48, (2a) for confirming the credibility of information in more credible texts was .58, (2b) for questioning the credibility of information in less credible texts was .79, (3a) for identifying main ideas from a single online text was .57, (3b) for synthesizing information across multiple online texts was .93, (4) and for communicating was .81. These factor scores were saved and standardized ($M = 0$, $SD = 1$). For our supplementary sample (23 students) in the current study, we calculated the ORC factor scores similarly, one student at a time, as we did above when calculating the reading fluency factor scores.

Next, the saved ORC factor scores were used to group students according to their ORC performance by applying latent profile analysis (LPA). LPA is a person-centered approach that helps us understand individuals' different patterns of certain criteria variables (see, e.g., Mäkikangas et al., 2018). We applied LPA[1] to identify different online reading performance profiles in relation to the six ORC component skills. In these analyses, we used a robust maximum likelihood (MLR) estimator. Furthermore, in order to evaluate the model and choose the optimal number of profiles, we used Akaike information criteria (AIC), Bayesian information criteria (BIC), sample-size adjusted Bayesian information criteria (aBIC), and the Vuong-Lo-Mendell-Rubin (VLMR) and adjusted Lo-Mendell-Rubin (aLMR) likelihood ratio tests. The smaller the values of the AIC, BIC, and aBIC, the better the model (Nylund et al., 2007). The significant p-values (<.05) of the two likelihood ratio tests indicate the better fit of the estimated model

than the model with one fewer profile (Nylund et al., 2007). Furthermore, we reported entropy values for all models. Entropy values range from zero to one, and the values approaching one indicate a better fit (Asparouhov and Muthén, 2014a).

Alongside the aforementioned criteria, the substantive meaning and theoretical relevance of the model solutions were considered. We also reported the average latent class probabilities for the best-fitting LPA model. As recommended in previous research (see, e.g., Peugh and Fan, 2013), all LPA models were conducted with unequal means and variances across the profiles. Finally, we conducted auxiliary analyses in order to examine students' ORC profiles against the relevant criterion variables, such as students' learner groups and reading habits. As suggested by Asparouhov and Muthén (2014b), we used the DCAT option for categorical variables (learner group variables), and the BCH option for continuous variables (reading habit variables). To also be able to use the MLR estimator in the auxiliary analyses, we used saved BCH weights.

Results

Online Research and Comprehension Performance Profiles

To find the most appropriate model describing ORC performance, nine models were estimated. As shown in Table 3, the VLMR and aLMR tests suggested that a four-profile solution would provide the best fit. However, the information criteria, such as AIC, BIC, and aBIC, suggested that a model with additional profiles would be more suitable. All the aforementioned information criteria had lower values in the consequent solutions. We chose the model with a seven-profile solution because the BIC value started to increase in further solutions, and the entropy value did not get any better (Table 3). Based on previous research, BIC value seems to be the most relevant of the information criteria considered (Nylund et al., 2007). The seven-profile solution was able to describe the performance profiles in a detailed and comprehensible way. Moreover, the classification quality of the seven-profile solution was high: the average latent class probabilities for the most likely latent class membership varied between .87–.98.

Figure 2 shows the seven identified performance profiles: (1) very poor performers (7.6%), (2) poor performers (5.7%), (3) below-average performers (22.5%), (4) average performers with low questioning credibility scores (13.3%), (5) average performers (22.7%), (6) good performers (22.9%), and (7) top performers (5.3%). Most of the profiles were related to the level of performance across all six ORC component skills, with one exception. As Figure 2 shows, the average performers with low questioning credibility scores were quite near the average in other areas but performed below average in questioning the credibility of information in less credible texts.

Online Research and Comprehension Performance Profiles Among Different Learner Groups

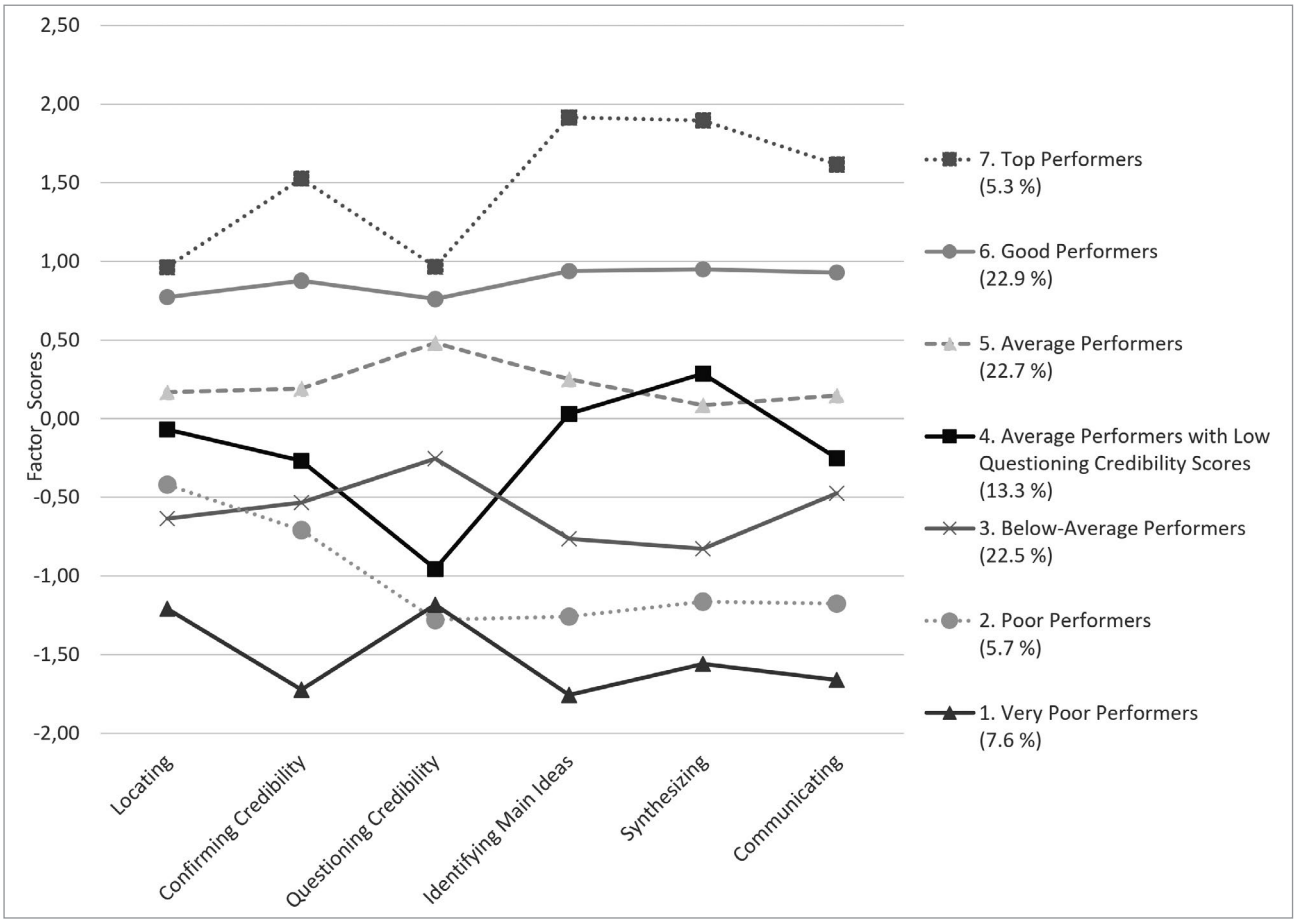
Table 4 shows the distributions of different learner groups and performance profiles with pairwise comparisons. When students had reading difficulties and/or difficulties with attention and EF, the level of their ORC performance decreased. The trend was the opposite among the students without identified difficulties. The proportion of students without these difficulties increased as the level of ORC performance increased. However, a few of students with

TABLE 3
Information Criteria, Statistical Tests, and Entropies of the Different Online Research and Comprehension Performance Profiles

Profiles	AIC	BIC	aBIC	VLMR (*p*)	aLMR (*p*)	Entropy
1	7447.89	7496.82	7458.74	-	-	-
2	6346.83	6448.77	6369.43	.000	.000	.88
3	5963.34	6118.29	5997.70	.002	.002	.87
4	5783.08	5991.04	5829.19	.03	.03	.88
5	5714.22	5975.18	5772.08	.26	.27	.87
6	5647.76	5961.74	5717.38	.02	.02	.89
7	5589.90	5956.89	5671.27	.06	.06	.89
8	5543.30	5963.29	5636.42	.19	.19	.89
9	5502.11	5975.12	5606.99	.25	.25	.89

Note. AIC = Akaike information criterion, BIC = Bayesian information criteria, aBIC = sample-size adjusted Bayesian information criterion, VLMR = Vuong-Lo-Mendell-Rubin likelihood ratio test, aLMR = Lo-Mendell-Rubin adjusted likelihood ratio test.

FIGURE 2
Performance in Each Component Skill by Online Research and Comprehension Performance Profiles



Note. Standardized factor scores for each component skill were used in the analyses.

the difficulties performed better than could be expected, based on their deficiencies.

Of the students with *reading difficulties*, 59.0% belonged to the lowest three performance profiles. Further, pairwise comparisons also showed that students with reading difficulties had a higher probability of being poor performers and below-average performers than a good or top performer. Of the students with teacher-rated *attention and EF difficulties*, 67.5% belonged to the lowest three performance profiles. Pairwise comparisons also showed that students with attention and EF difficulties had a higher probability of belonging to the group of very poor performers and below-average performers than belonging to the highest performance profiles. Notably, the proportion of students with attention and EF difficulties (30.3%) in the lowest performance profile was higher than the proportion of students with reading difficulties (12.1%). From students with *comorbid difficulties* in reading as well as attention and EF, 82.4% belonged to the lowest three performance profiles. Pairwise comparisons showed that students with comorbid difficulties had a higher probability of being very poor performers and below-average performers than either good or top performers.

Of note is that some students with the aforementioned difficulties performed at average and good levels of ORC: 27.5% of students with reading difficulties and 16.2% of students with attention and EF difficulties belonged either to the group of average performers or to the group of good performers. Only one student with comorbid difficulties reached the level of average performers. From students without these identified difficulties, only 4.4% belonged to the group of very poor performers, and only 3.8% to the group of poor performers. Further, all top performers were students without identified difficulties.

Online Research and Comprehension Performance Profiles and Reading Habits

As shown in Table 5, reading books had the strongest association with students' ORC performance. When compared to all other performance profiles, very poor performers ($M = 1.78$) read books very seldom, less than 1–2 times per

TABLE 4
Distributions of Learner Groups in Different Online Research and Comprehension Performance Profiles and the Significance of the Differences of Distributions Between the Profiles

Criterion Variable		1. Very Poor Performers	2. Poor Performers	3. Below-Average Performers	4. Average Performers with Low Questioning Credibility Scores	5. Average Performers	6. Good Performers	7. Top Performers	Total f / % Within LD Group	Overall Test for Equality of Distributions	Pairwise Comparisons
Students with Reading Difficulties	*f*	4	6	13	6	6	4	0	39	$\chi2(6)$ = 43.72, p <.001	2, 3 > 6, 7 4, 5 > 7
	% within a learner group	10.30	15.40	33.30	15.40	15.40	10.30	0.00	100		
	% within a profile	12.10	24.00	13.30	10.30	6.10	4.00	0.00			
	SE	0.07	0.10	0.04	0.05	0.03	0.02	0.00			
Students with Attention and Executive Function Difficulties	*f*	10	4	11	6	4	2	0	37	$\chi2(6)$ = 43.04, p <.001	1 > 3, 5, 6, 7 3 > 6, 7
	% within a learner group	27.00	10.80	29.70	16.20	10.80	5.40	0.00	100		
	% within a profile	30.30	16.00	11.20	10.30	4.00	2.00	0.00			
	SE	0.09	0.09	0.04	0.07	0.02	0.01	0.00			
Students with Comorbid Difficulties in Reading and Attention and Executive Function	*f*	4	2	8	2	1	0	0	17	$\chi2(6)$ = 18.55, p =.005	1, 3 > 4, 6, 7
	% within a learner group	23.50	11.80	47.10	11.80	5.90	0.00	0.00	100		
	% within a profile	12.10	8.00	8.20	3.40	1.00	0.00	0.00			
	SE	0.07	0.06	0.03	0.00	0.01	0.00	0.00			
Students Without Identified Difficulties	*f*	15	13	66	44	88	94	23	343		
	% within a learner group	4.40	3.80	19.20	12.80	25.70	27.40	6.70	100		
	% within a profile	45.50	52.00	67.30	75.90	88.90	94.00	100.00			
Total	*f*	33	25	98	58	99	100	23	436		
	% within a profile	100	100	100	100	100	100	100			

Note. Frequencies and proportions of learners belonging to a certain performance profile is based on probabilities.

TABLE 5
Students' Reading Habits in Different Online Research and Comprehension Performance Profiles and the Significance of the Differences of Distributions Between the Profiles

Criterion Variable	1. Very Poor Performers		2. Poor Performers		3. Below-Average Performers		4. Average Performers with Low Questioning Credibility Scores		5. Average Performers		6. Good Performers		7. Top Performers		Overall Test for Equality of Distributions	Pairwise Comparisons
	M	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*		
Print Reading Habits																
Books	1.78	0.17	2.38	0.20	2.60	0.13	2.83	0.17	2.88	0.13	3.33	0.13	3.47	0.32	$\chi^2(6) = 67.67$, $p < .001$	1 < 2, 3, 4, 5, 6, 7 2 < 5, 6, 7 3 < 6, 7 4, 5 < 6
Newspapers	1.94	0.20	1.52	0.16	1.80	0.09	1.89	0.14	2.20	0.13	2.02	0.12	1.71	0.19	$\chi^2(6) = 15.19$, $p < .05$	2 < 5, 6 3, 7 < 5
Magazines	1.81	0.18	1.34	0.10	1.57	0.09	2.02	0.17	1.95	0.11	1.93	0.09	1.67	0.13	$\chi^2(6) = 31.53$, $p < .001$	2 < 1, 4, 5, 6, 7 3 < 4, 5, 6
Comics	2.41	0.17	2.67	0.23	2.99	0.15	2.75	0.19	2.75	0.15	2.82	0.15	2.54	0.28	$\chi^2(6) = 7.29$, $p = .30$	-
Digital Reading Habits																
Ebooks	1.00	0.00	1.00	0.00	1.10	0.05	1.07	0.05	1.08	0.04	1.11	0.05	1.13	0.14	$\chi^2(6) = 20.25$, $p < .01$	1, 2 < 3, 5, 6
Online Newspapers	1.93	0.22	1.78	0.20	2.10	0.12	2.07	0.19	2.07	0.14	2.10	0.12	2.13	0.28	$\chi^2(6) = 2.57$, $p = .86$	-
Websites	2.16	0.19	2.20	0.17	2.27	0.11	2.41	0.15	2.47	0.10	2.60	0.11	2.69	0.20	$\chi^2(6) = 10.99$, $p = .09$	-
Blog Posts	1.30	0.15	1.18	0.09	1.49	0.09	1.55	0.13	1.50	0.10	1.83	0.12	1.73	0.17	$\chi^2(6) = 25.45$, $p < .001$	1, 3, 5 < 6 2 < 3, 4, 5, 6, 7
Forums	1.84	0.22	1.50	0.12	1.71	0.11	1.62	0.15	1.78	0.11	1.82	0.11	1.88	0.24	$\chi^2(6) = 5.56$, $p = .47$	-

Note. Observed range in all variables 1–5.

month. Further, poor performers (M = 2.38) and below-average performers (M = 2.60) read books less frequently than good (M = 3.33) and top performers (M = 3.47). There were also differences in reading books for those performing at the average levels of ORC. For instance, average performers with low questioning credibility scores (M = 2.83) and average performers (M = 2.88) both read books less frequently than good performers.

Our results also show that poor performers (M = 1.52) read newspapers less frequently than, for example, average performers (M = 2.20) and good performers (M = 2.02). Interestingly, poor performers did not differ from top performers (M = 1.71), but this may be because both profiles consist of less than 6% of the students in the whole sample. Further, poor performers (M = 1.34) and below-average performers (M = 1.57) read magazines less frequently than, for example, average performers (M = 1.95) and good performers (M = 1.93). Another interesting finding is that the group of very poor performers did not differ from the highest-performing profiles in reading newspapers and magazines. Finally, the profiles did not differ in the reading frequency of comics.

When we compared students' ORC profiles in relation to their digital reading habits, we noticed that very poor performers (M = 1.30), poor performers (M = 1.18), below-average performers (M = 1.49), and average performers (M = 1.50) all read blog posts somewhat less frequently than good performers (M = 1.83). Further, sixth-grade students also differed from each other in the reading frequency of ebooks, but the differences were very small, as students of this age read ebooks very seldom. We did not find any differences between students representing different ORC profiles with regard to reading online newspapers, websites, and forums. Overall, the mean values showed that students seemed to read print texts more often than digital texts. However, our results suggest that the medium does not matter as much as the length of the texts. It seems that reading longer texts (books and blog posts), in particular, is associated with students' online research and comprehension performance.

Discussion

This study sheds light on inter-individual differences in students' online research and comprehension performance. First, we were interested in exploring students' ORC performance profiles by using a person-centered approach, specifically latent profile analysis. Second, as most previous research has concentrated on regular learners, this study provides new knowledge about how students with reading difficulties, difficulties in attention and EF, or comorbid difficulties in both areas are able to face the demands of working with online information. Third, as an additional layer of investigation, we also provide information on how students' reading habits are associated with their ORC performance.

Online Research and Comprehension Performance Profiles

When examining students' ORC performance with latent profile analysis, we captured seven profiles. The profiles, with one exception, reflected students' performance levels across all six ORC component skills, ranging from very poor performance to top performance. This is to say that students who belonged to very poor performers or poor performers struggled more or less with all component skills, whereas good and top performers were quite skilled or skilled in all areas.

For example, top performers were very likely able to effectively locate relevant resources and adequately evaluate the credibility of resources regardless of their quality. Top performers were particularly skilled in identifying relevant ideas from single resources, synthesizing ideas across resources, and communicating a justified, source-based stance in their emails. In contrast, it was highly likely that very poor performers did not perform well in any of these areas. For instance, very poor performers were slow in locating relevant online resources and inadequate in evaluating the credibility of these resources. They identified only a limited number of the main ideas presented in the resources and remained short and shallow when communicating their stance in the email. The ORC performance of students who belonged to the profiles of below-average and average performers fell between these extremes.

The profiles reflecting performance levels across different component skills are in line with our previous research showing that although all six ORC components independently contribute to students' online reading performance, they also form a common construct of students' ORC performance (Kanniainen et al., 2019). Interestingly, there was one profile that did not merely reflect the performance level across all the component skills. This profile was labeled average performers with low questioning credibility scores. Students belonging to this profile were quite near the average in other areas but performed clearly below the average in questioning the credibility of information in less credible texts. This result suggests that questioning the credibility of an online resource that is biased or lacks expertise is particularly challenging for some students (Kiili et al., 2018; Pérez et al., 2018).

Finally, we applied (see footnote 1) the multilevel latent profile analysis to examine whether the proportional distributions of the single-level ORC profiles varied across classrooms. However, we did not find any statistically significant differences as a function of students' classrooms. Nevertheless, these kinds of multilevel differences may be possible with a larger sample; this remains for future work to explore.

How Do Students with Reading Difficulties and/or Difficulties in Attention and Executive Function Perform Online?

Our results indicate that students with reading difficulties also face difficulties when reading to learn from online information. This finding is aligned with previous research showing that slow and inaccurate decoding and reading fluency are often associated with difficulties in reading comprehension (e.g., Hulme et al., 2015; Lyon et al., 2003) and that poor comprehension skills are associated with low ORC performance (Coiro, 2011; Kanniainen et al., 2019). Web-based reading environments may also place an extra demand on students with reading difficulties if text and knowledge construction require written responses, as was the case in the ORC task we used. Namely, recent review studies (Galuschka et al., 2020; Reis et al., 2020) have shown that writing difficulties are very common among learners with reading difficulties.

In addition, students with teacher-rated attention and EF difficulties faced challenges online, as has also been shown in previous studies (Caccia et al., 2019; Kanniainen et al., 2021). Interestingly, the proportion of students with difficulties in attention and EF in the profile of very poor performers was much higher than the proportion of students with reading difficulties. Attention and EF difficulties rated by teachers included, for instance, difficulties focusing attention on instructions and difficulties completing tasks. This finding suggests the severe nature of difficulties in attention and EF when reading to learn from online information. Specifically, during the ORC task, students were required to focus and shift their attention between different online reading processes, such as critical evaluation of information, and synthesizing information across multiple online texts. They were also required to focus and shift between different kinds of information locating and writing tools, such as a search engine, a social networking site, and a notetaking tool. It might be that there was not enough working memory capacity left for planning and writing their answers, even though students were able to use the notetaking tool. Successful meaning construction in written responses requires planning, as planning enables writers to construct meanings by organizing their ideas into a meaningful structure (e.g., Flower and Hayes, 1981; McNamara et al., 2019).

Comorbid difficulties in reading and attention and EF caused the most severe difficulties in students' ORC performance, suggesting the need for instruction that could support these students' ORC performance. Additionally, there were also students without these identified difficulties who nonetheless had significant difficulties in the ORC task. This indicates the importance of additional work designed to understand what causes these students' poor performance. For instance, do motivational aspects play a role beyond cognitive processes (see, e.g., Afflerbach, 2016)? Aspects such as boredom and frustration have been speculated to cause poor performance in multiple text reading if students, for example, end up interrupting their task execution too early (List and Alexander, 2019).

Surprisingly, a couple of students with reading difficulties or difficulties in attention and EF performed better than would be expected based on their deficiencies. This finding suggests that these students may have developed compensatory strategies to overcome the challenges of online reading. For example, Leinonen et al. (2001) found that some adult learners with reading difficulties seem not to be disturbed by their errors when reading. They also found that some of these struggling adult readers reported reading a large number of books per year, which seemed to enhance their lexicon and thus compensate for their inaccurate reading fluency. Our result that good ORC performers reported reading books more frequently than, for example, very poor and poor performers may indicate that reading books could be one compensatory mechanism for those above-average performing students with reading difficulties or difficulties in attention and EF.

Further, in a small case study by Castek et al. (2011), they noticed that two of the four struggling readers were able to manage multiple windows effectively when, for example, reading a task assignment in one window and using a search engine in another, the browser window. Also, Andresen et al. (2019b) found that in a group of four students with reading difficulties, there was one who was able to compensate for reading deficiencies by dedicating time to the task. However, more research is needed to understand students' possible compensatory strategies and mechanisms for overcoming their reading difficulties or difficulties in attention and EF when working with online information. This understanding would help educators in designing instruction to address the needs of students with difficulties.

Students' Reading Habits in Different Online Reading Profiles

With respect to students' reading habits and their online research and comprehension performance, we found that reading books had the strongest association with students' ORC performance profiles over reading newspapers, magazines, and comics. This finding supports evidence from traditional reading research showing strong relations between students' book-reading frequency and reading comprehension level over reading of other materials (Pfost et al., 2013; Spear-Swerling et al., 2010; Torppa et al., 2020). Reading books has also been found to be a strong predictor of students' vocabulary (Pfost et al., 2013), and vocabulary knowledge again seems to be associated with comprehension (for a review, see Cervetti and Wright, 2020).

In contrast to traditional reading research, in which digital reading habits have shown negative associations with students' reading comprehension (Pfost et al., 2013; Torppa et al., 2020), we found that reading blog posts and ebooks was positively associated with students' ORC performance profiles. Reading online newspapers, websites, and online forums, however, had no associations. These partly contradictory findings might relate to the fact that traditional reading research has seen digital reading habits somewhat narrowly from the perspective of social online engagement. For example, Pfost et al. (2013) and Torppa et al. (2020) included reading materials such as emails, instant messages, and forum posts, but not any materials, such as ebooks and online news (cf. Lupo et al., 2017). Moreover, even though Torppa et al. (2020) also included blog posts, they included all the digital texts under the same composite score. However, their relatively low alphas (varying between .46–53 in grades six to nine) seem not to support the unidimensional nature of reading different forms of digital texts. Thus, our findings that reading blog posts and ebooks is associated with ORC positively seems noteworthy. To make the comparison between previous studies and the present study easier for the reader, we also included a correlation matrix of the students' ORC component skills and reading habits in Appendix B.

Based on the latent profiling, of note is that reading longer and more vocabulary-rich texts, such as books, blog posts, and ebooks, was associated with students' online reading performance, while reading texts that were shorter in length and probably narrower in vocabulary, for example comics and online forum posts, had no statistically significant associations. Blog posts have been seen as less reliable online resources because blogs are often personal publishing (e.g., Perez et al., 2018). Some, however, do see blogs as useful, at least for second language vocabulary learning (Arndt and Woore, 2018). Further, even though the sixth graders did not, for instance, differ in reading online news, and they read ebooks quite rarely, reading these kinds of digital texts may become a stronger predictor among older students, as students' attitudes toward print and digital reading are often changeable and older students seem to prefer digital media (Jang et al., 2021). Saying this, we should be cautious in giving a certain image that reading digital text has only a negative influence on comprehension. In fact, text length and richness seem to matter more than the reading medium. We could leverage this understanding into advanced pedagogies that reading longer and versatile texts both on paper and on digital formats may have a positive influence on learners' ORC performance.

Limitations and Future Research

The present study has five important limitations that suggest avenues for future work. First, the ORC assessment scores may provide an overestimation of students' online reading skills. This is because there were prompts and guidance included in the assessment. For instance, the avatar gave the right link to the correct online resource if a student failed the locating task. However, in real-world online reading situations (e.g., using the Internet and search engines to complete school assignments), students are not typically provided with the correct online resource. Thus, especially students with different learning-related difficulties may get frustrated and quit the task faster if they are unable to locate relevant online resources. Although this remains for future studies to investigate, practitioners should be aware of this overestimation possibility and, for example, pay close attention to how poor locating skills can influence students' ORC performance even more in real-world web-based reading environments. However, our choice for this task design allowed us to investigate performance in the other tasks measuring other component skills of ORC (e.g., evaluation of the credibility of information) without the consequence of failing to find the right webpages, i.e., as an independent separate skill.

Second, some of the saved ORC factor scores, especially locating, had a low omega reliability value. This low level of reliability may, for example, stem from the limited number of items on the locating component, and thus lead to reduced accuracy of classifications. In other words, there could have been, for instance, average ORC performers with particularly low locating scores; this remains for future work to explore. Nevertheless, the average latent class probabilities showed that the seven ORC performance profiles distinguished well with latent class membership varying between .87–.98. In addition, the 95% confidence intervals of each profile groups' mean scores in the six ORC component skills mainly support the seven-profile solution. The 95% confidence error bars are presented in a bar chart in Appendix C.

Third, for practical reasons, we had a limited amount of time to test students in schools, and thus, we were not able to examine to what extent other cognitive skills, such as working memory capacity, play a role in the ORC performance of students with reading difficulties and/or difficulties in attention and EF (cf. Andresen et al., 2019a; Andresen et al., 2019b). In addition, we did not include any process data, such as verbal protocols and response times, to access the students' online strategies. It remains for future studies to examine the strategies that students with reading difficulties and/or attention and EF difficulties use when reading online, including potential compensatory strategies. Such work could help to inform issues such as reading contexts in which online- and offline-reading skills might best be developed. Future work may also benefit from using performance-based measures of reading habits in addition to the informant-based questionnaires. Following the procedure of the Magazine Recognition Test designed by Stanovich and West (1989), it

would be interesting to develop a recognition test for blogs, for example.

Fourth, we did not have diagnoses, such as dyslexia and ADHD diagnoses, available for all the participating students. For some students, parents reported that reading difficulties and/or difficulties in attention had been identified, but as a formal diagnosis is not a prerequisite for special educational support in Finland, not all students with such difficulties have one. However, we used three different tests for reading fluency that met the criteria displayed for difficulties, such as inaccurate, poor word recognition and decoding skills (Lyon et al., 2003). In addition, the teacher-rating inventory for difficulties in attention and EF has shown good criterion validity (Klenberg et al., 2010a) with the ADHD Rating Scale–IV: School Version (DuPaul et al., 1998).

Finally, the number of students in the comorbidity group was small, which means that the level of diversity may be underestimated in this group. In other words, with a larger group size, also some students with comorbid difficulties could for example appear in the group of good performers. However, in this way our sample better corresponds to the normal population, as it is estimated that 5–15% of school-age children struggle with difficulties related to their learning (American Psychiatric Association, 2018), and in about 15–40% of these cases, learners with reading difficulties, also have, for instance, difficulties in attention and EF (Shaywitz et al., 1995; Willcutt and Pennington, 2000; Willcutt et al., 2005). Thus, the group of 17 students with comorbid difficulties is in line with the previously reported prevalence of these difficulties (hypothetical range in this sample: 3–26 students). It should be noted, at the same time, that our overall sample size is rather big.

Conclusions and Implications

This study broadens our understanding of how students with difficulties in reading and/or difficulties in attention and EF engage in learning from online information. We classified seven latent online research and comprehension performance profiles, from very poor performers to top performers. Not unexpectedly, students with the aforementioned difficulties performed generally lower in ORC than did students without the difficulties. Interestingly, some students—though very few—performed at average and good levels of ORC despite their reading difficulties or difficulties in attention and EF. Students' reading habits, especially reading longer texts, may be supportive for their ORC performance. However, current design does not allow causal conclusions. Active reading may be one of the compensatory mechanisms for well-performing students with reading difficulties or difficulties in attention and EF use, but more research is needed. Further, learning aids and structured learning environments may be beneficial. Consequently, we need courses of action to find more compensatory and supportive elements of online research and comprehension performance for students with reading difficulties and/or difficulties in attention and EF.

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Conflict of Interest Disclosure

Declarations of interest: none.

Ethics Approval Statement

Data and procedures have met the ethical guidelines from our institutions. The Ethical Committee of the University of Jyväskylä gave its approval, and the guardians signed a written consent form for their children's participation.

Permission to Reproduce Material from Other Sources

There is no such material in the manuscript.

Author Contributions

Laura Kanniainen, Conceptualization; data collection, analysis and interpretation; writing – original draft; writing – review & editing.

Carita Kiili, Conceptualization; data collection, analysis and interpretation; resources; supervision; writing – review & editing.

Asko Tolvanen, Methodology: data analysis; writing – review & editing.

Jukka Utriainen, Methodology: data analysis; writing – review & editing.

Mikko Aro, Conceptualization; supervision; writing – review & editing.

Donald J. Leu, Conceptualization; resources; supervision; writing – review & editing.

Paavo H.T. Leppänen, Conceptualization; funding acquisition; project administration; supervision; writing – review & editing.

Data Availability Statement

The data that have been used are confidential.

NOTE

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[1] As students were nested within 24 different classrooms and eight schools, we calculated intra-class correlations for the six ORC factor included in the LPA. The analysis showed that 0–1.1% of the variance was explained by the differences at the school level and 2.4–7.8% at the classroom level. Thus, multilevel latent profile analysis (MLPA) was used to examine whether the proportional distributions of the single-level profiles varied across the upper-level classes (Mäkikangas et al., 2018). In other words, we used MLPA to examine whether the probability that a student belonged to a specific online research and comprehension profile varied significantly across the classrooms and teachers. However, we did not find a statistically significantly larger probability that a student would belong to a certain profile in some classrooms or with some teachers than in other classrooms or with other teachers (p-values >.05).

REFERENCES

Afflerbach, P. (2016). An overview of individual differences in reading: Research, policy, and practice. In P. Afflerbach (Ed.), *Handbook of individual differences in reading: Reader, text, and context* (pp. 1–12). Routledge.

American Psychiatric Association. (2018). *What is specific learning disorder?* Retrieved June, 28, 2021 from https://www.psychiatry.org/patients-families/specific-learning-disorder/what-is-specific-learning-disorder

Andresen, A., Anmarkrud, Ø., & Bråten, I. (2019a). Investigating multiple source use among students with and without dyslexia. *Reading and Writing*, *32*(5), 1149–1174. https://doi.org/10.1007/s11145-018-9904-z

Andresen, A., Anmarkrud, Ø., Salmerón, L., & Bråten, I. (2019b). Processing and learning from multiple sources: A comparative case study of students with dyslexia working in a multiple source multimedia context. *Frontline Learning Research*, *7*(3), 1–26 https://doi.org/10.14786/flr.v7i3.451

Anmarkrud, Ø., Brante, E. W., & Andresen, A. (2018). Potential processing challenges of Internet use among readers with dyslexia. In J. L. G. Braasch, I. Bråten, & M. T. McCrudden (Eds.), *Handbook of multiple source use* (pp. 117–132). Routledge. https://doi.org/10.4324/9781315627496

Arndt, H. L., & Woore, R. (2018). Vocabulary learning from watching YouTube videos and reading blog posts. *Language Learning & Technology*, *22*(3), 124–142. https://doi.org/10125/44660

Asparouhov, T., & Muthén, B. (2014a). Auxiliary variables in mixture modeling: Three-step approaches using M plus. *Structural Equation Modeling: A Multidisciplinary Journal*, *21*(3), 329–341. https://doi.org/10.1080/10705511.2014.915181

Asparouhov, T., & Muthén, B. (2014b). Auxiliary variables in mixture modeling: Using the BCH method in Mplus to estimate a distal outcome model and an arbitrary secondary model. *Mplus Web Notes*, *21*(2), 1–22 https://www.statmodel.com/download/asparouhov_muthen_2014.pdf

Barzilai, S., Zohar, A. R., & Mor-Hagani, S. (2018). Promoting integration of multiple texts: A review of instructional approaches and practices. *Educational Psychology Review*, *30*(3), 973–999. https://doi.org/10.1007/s10648-018-9436-8

Björn, P. M., Aro, M., Koponen, T., Fuchs, L. S., & Fuchs, D. (2016). The many faces of special education within RTI frameworks in the United States and Finland. *Learning Disability Quarterly*, *39*(1), 58–66. https://doi.org/10.1177/0731948715594787

Braasch, J. L., Bråten, I., Strømsø, H. I., Anmarkrud, Ø., & Ferguson, L. E. (2013). Promoting secondary school students' evaluation of source features of multiple documents. *Contemporary Educational Psychology*, *38*(3), 180–195. https://doi.org/10.1016/j.cedpsych.2013.03.003

Braasch, J. L., Rouet, J. F., Vibert, N., & Britt, M. A. (2012). Readers' use of source information in text comprehension. *Memory & Cognition*, *40*(3), 450–465. https://doi.org/10.3758/s13421-011-0160-6

Brandão, A. C. P., & Oakhill, J. (2005). "How do you know this answer?" – Children's use of text data and general knowledge in story comprehension. *Reading and Writing*, *18*(7), 687–713. https://doi.org/10.1007/s11145-005-5600-x

Brand-Gruwel, S., Wopereis, I., & Walraven, A. (2009). A descriptive model of information problem solving while using internet. *Computers & Education*, *53*(4), 1207–1217. https://doi.org/10.1016/j.compedu.2009.06.004

Butterfuss, R., & Kendeou, P. (2018). The role of executive functions in reading comprehension. *Educational Psychology Review*, *30*(3), 801–826. https://doi.org/10.1007/s10648-017-9422-6

Caccia, M., Giorgetti, M., Toraldo, A., Molteni, M., Sarti, D., Vernice, M., & Lorusso, M. L. (2019). ORCA. IT: A new web-based tool for assessing online reading, search and comprehension abilities in students reveals effects of gender, school type and reading ability. *Frontiers in Psychology*, *10*, 2433. https://doi.org/10.3389/fpsyg.2019.02433

Cain, K., & Bignell, S. (2014). Reading and listening comprehension and their relation to inattention and hyperactivity. *British Journal of Educational Psychology*, *84*(1), 108–124. https://doi.org/10.1111/bjep.12009

Cain, K., Oakhill, J. V., Barnes, M. A., & Bryant, P. E. (2001). Comprehension skill, inference-making ability, and their relation to knowledge. *Memory & Cognition*, *29*(6), 850–859. https://doi.org/10.3758/BF03196414

Castek, J., Zawilinski, L., McVerry, J. G., O'Byrne, W. I., & Leu, D. J. (2011). The new literacies of online reading comprehension: New opportunities and challenges for students with learning difficulties. In C. Wyatt-Smith, J. Elkins, & S. Gunn (Eds.), *Multiple perspectives on difficulties in learning literacy and numeracy* (pp. 91–110). Springer. https://doi.org/10.1007/978-1-4020-8864-3_4

Cervetti, G. N., & Wright, T. S. (2020). The role of knowledge in understanding and learning from text. In E. Birr Moje, P. P. Afflerbach, P. Enciso, & N. K. Lesaux (Eds.), *Handbook of reading research, volume V* (pp. 237–260). Routledge. https://doi.org/10.4324/9781315676302

Cho, B., & Afflerbach, P. (2015). Reading on the internet. Realizing and constructing potential texts. *Journal of Adolescent & Adult Literacy*, *58*(6), 504–517. https://doi.org/10.1002/jaal.387

Cho, B. Y., Woodward, L., & Li, D. (2018). Epistemic processing when adolescents read online: A verbal protocol analysis of more and less successful online readers. *Reading Research Quarterly*, *53*(2), 197–221. https://doi.org/10.1002/rrq.190

Cho, B. Y., Woodward, L., Li, D., & Barlow, W. (2017). Examining adolescents' strategic processing during online reading with a question-generating task. *American Educational Research Journal*, *54*(4), 691–724. https://doi.org/10.3102/0002831217701694

Coiro, J. (2011). Predicting reading comprehension on the Internet: Contributions of offline reading skills, online reading skills, and prior knowledge. *Journal of Literacy Research*, *43*(4), 352–392. https://doi.org/10.1177/1086296X11421979

Coiro, J., Coscarelli, C., Maykel, C., & Forzani, E. (2015). Investigating criteria that seventh graders use to evaluate the quality of online information. *Journal of Adolescent & Adult Literacy*, *59*(3), 287–297. https://doi.org/10.1002/jaal.448

Coiro, J., & Dobler, E. (2007). Exploring the online reading comprehension strategies used by sixth-grade skilled readers to search for and locate information on the Internet. *Reading Research Quarterly*, *42*(2), 214–257. https://doi.org/10.1002/jaal.448

Cromley, J. G. (2020). Commentary: Analyzing strategic: Processing pros and cons of different methods. In D. L. Dinsmore, L. K. Fryer, & M. M. Parkinson (Eds.), *Handbook of strategies and strategic processing* (pp. 393–405). Routledge. https://doi.org/10.4324/9780429423635

Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, *64*, 135–168. https://doi.org/10.1146/annurev-psych-113011-143750

Dinsmore, D. L., & Alexander, P. A. (2016). A multidimensional investigation of deep-level and surface-level processing. *The Journal of Experimental Education*, *84*(2), 213–244. https://doi.org/10.1080/00220973.2014.979126

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education*, *84*(3), 287–312. https://doi.org/10.1002/(SICI)1098-237X(200005)84:3%3C287:AID-SCE1%3E3.0.CO;2-A

DuPaul, G. J., Power, T. J., Anastopoulos, A. D., & Reid, R. (1998). *ADHD Rating Scale–IV: Checklists, norms, and clinical interpretation*. Guilford Press.

Eklund, K., Torppa, M., Aro, M., Leppänen, P. H., & Lyytinen, H. (2015). Literacy skill development of children with familial risk for dyslexia through grades 2, 3, and 8. *Journal of Educational Psychology*, *107*(1), 126–140. https://doi.org/10.1037/a0037121

Eurostat. (2013). *European social statistics*. Publications Office of the European Union. https://doi.org/10.2785/36105

Flower, L., & Hayes, J. R. (1981). A cognitive process theory of writing. *College Composition and Communication*, *32*(4), 365–387. https://doi.org/10.2307/356600

Follmer, D. J. (2018). Executive function and reading comprehension: A meta-analytic review. *Educational Psychologist*, *53*(1), 42–60. https://doi.org/10.1080/00461520.2017.1309295

Fraillon, J., Ainley, J., Schulz, W., Friedman, T., & Duckworth, D. (2020). *Preparing for life in a digital world. IEA International computer and information literacy study 2018 international report*. Springer Nature. https://doi.org/10.1007/978-3-030-38781-5

Friedman, N. P., & Miyake, A. (2017). Unity and diversity of executive functions: Individual differences as a window on cognitive structure. *Cortex*, *86*, 186–204. https://doi.org/10.1016/j.cortex.2016.04.023

Fuchs, L. S., Fuchs, D., Hosp, M. K., & Jenkins, J. R. (2001). Oral reading fluency as an indicator of reading competence: A theoretical, empirical, and historical analysis. *Scientific Studies of Reading*, *5*, 239–256. https://doi.org/10.1207/S1532799XSSR0503_3

Galuschka, K., Görgen, R., Kalmar, J., Haberstroh, S., Schmalz, X., & Schulte-Körne, G. (2020). Effectiveness of spelling interventions for learners with dyslexia: A meta-analysis and systematic review. *Educational Psychologist*, *55*(1), 1–20. https://doi.org/10.1080/00461520.2019.1659794

Gough, P. B., & Tunmer, W. E. (1986). Decoding, reading, and reading disability. *Remedial and Special Education*, *7*, 6–10. https://doi.org/10.1177/074193258600700104

Hahnel, C., Goldhammer, F., Kröhne, U., & Naumann, J. (2018). The role of reading skills in the evaluation of online information gathered from search engine environments. *Computers in Human Behavior*, *78*, 223–234. https://doi.org/10.1016/j.chb.2017.10.004

Hämäläinen, E. K., Kiili, C., Marttunen, M., Räikkönen, E., González-Ibáñez, R., & Leppänen, P. H. (2020). Promoting sixth graders' credibility evaluation of web pages: An intervention study. *Computers in Human Behavior*, *110*, 106372. https://doi.org/10.1016/j.chb.2020.106372

Hautala, J., Kiili, C., Kammerer, Y., Loberg, O., Hokkanen, S., & Leppänen, P. H. (2018). Sixth graders' evaluation strategies when reading Internet search results: An eye-tracking study. *Behaviour & Information Technology*, *37*(8), 761–773. https://doi.org/10.1080/0144929X.2018.1477992

Henry, L. A., Castek, J., O'Byrne, W. I., & Zawilinski, L. (2012). Using peer collaboration to support online reading, writing, and communication: An empowerment model for struggling readers. *Reading & Writing Quarterly*, *28*(3), 279–306. https://doi.org/10.1080/10573569.2012.676431

Hoijtink, H. (2001). Confirmatory latent class analysis: Model selection using Bayes factors and (pseudo) likelihood ratio statistics. *Multivariate Behavioral Research*, *36*(4), 563–588. https://doi.org/10.1207/S15327906MBR3604_04

Holopainen, L., Kairaluoma, L., Nevala, J., Ahonen, T., & Aro, M. (2004). *Lukivaikeuksien seulontamenetelmä nuorille ja aikuisille [Dyslexia screening test for youth and adults]*. Niilo Mäki Instituutti.

Holopainen, L., Kiuru, N., Mäkihonko, M., & Lerkkanen, M. K. (2018). The role of part-time special education supporting students with reading and spelling difficulties from grade 1 to grade 2 in Finland. *European Journal of Special Needs Education*, *33*(3), 316–333. https://doi.org/10.1080/08856257.2017.1312798

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*, 1–55. https://doi.org/10.1080/10705519909540118

Hulme, C., Nash, H. M., Gooch, D., Lervåg, A., & Snowling, M. J. (2015). The foundations of literacy development in children at familial risk of dyslexia. *Psychological Science*, *26*(12), 1877–1886. https://doi.org/10.1177/0956797615603702

Jang, B. G., Ryoo, J. H., & Smith, K. C. (2021). Latent profiles of attitudes toward print and digital reading among adolescents. *Reading and Writing*, *34*(5), 1115–1139. https://doi.org/10.1007/s11145-020-10104-7

Kanniainen, L., Kiili, C., Tolvanen, A., Aro, M., Anmarkrud, Ø., & Leppänen, P. H. (2021). Assessing reading and online research comprehension: Do difficulties in attention and executive function matter? *Learning and Individual Differences*, *87*, 101985. https://doi.org/10.1016/j.lindif.2021.101985

Kanniainen, L., Kiili, C., Tolvanen, A., Aro, M., & Leppänen, P. H. (2019). Literacy skills and online research and comprehension: Struggling readers face difficulties online. *Reading and Writing*, *32*(9), 2201–2222. https://doi.org/10.1007/s11145-019-09944-9

Kiili, C., Bråten, I., Kullberg, N., & Leppänen, P. H. (2020). Investigating elementary school students' text-based argumentation with multiple online information resources. *Computers & Education*, *147*, 103785. https://doi.org/10.1016/j.compedu.2019.103785

Kiili, C., Leu, D. J., Utriainen, J., Coiro, J., Kanniainen, L., Tolvanen, A., Lohvansuu, K., & Leppänen, P. H. (2018). Reading to learn from online information: Modeling the factor structure. *Journal of Literacy Research*, *50*(3), 304–334. https://doi.org/10.1177/1086296X18784640

Kingsley, T., & Tancock, S. (2014). Internet inquiry: Fundamental competencies for online comprehension. *The Reading Teacher*, *67*(5), 389–399. https://doi.org/10.1002/trtr.1223

Kintsch, W. (1998). *Comprehension: A paradigm for cognition*. Cambridge University Press.

Kinzer, C. K., & Leu, D. J. (2017). New Literacies and new literacies within changing digital environments. In M. A. Peters (Ed.), *Encyclopedia of educational philosophy and theory*. Springer.

Klenberg, L., Jämsä, S., Häyrinen, T., & Korkman, M. (2010a). *Keskittymiskysely käsikirja [The attention and executive function rating inventory (ATTEX), handbook]*. Psykologien Kustannus.

Klenberg, L., Jämsä, S., Häyrinen, T., Lahti-Nuuttila, P., & Korkman, M. (2010b). The Attention and Executive Function Rating Inventory (ATTEX): Psychometric properties and clinical utility in diagnosing ADHD subtypes. *Scandinavian Journal of Psychology*, *51*(5), 439–448. https://doi.org/10.1111/j.1467-9450.2010.00812.x

LaBerge, D., & Samuels, S. J. (1974). Toward a theory of automatic information processing in reading. *Cognitive Psychology*, *6*, 293–323. https://doi.org/10.1016/0010-0285(74)90015-2

Leinonen, S., Müller, K., Leppänen, P. H., Aro, M., Ahonen, T., & Lyytinen, H. (2001). Heterogeneity in adult dyslexic readers: Relating

processing skills to the speed and accuracy of oral text reading. *Reading and Writing*, *14*(3), 265–296. https://doi.org/10.1023/A:1011117620895

Leu, D. J., Forzani, E., Rhoads, C., Maykel, C., Kennedy, C., & Timbrell, N. (2015). The new literacies of online research and comprehension: Rethinking the reading achievement gap. *Reading Research Quarterly*, *50*(1), 37–59. https://doi.org/10.1002/rrq.85

Leu, D.J., Kinzer, C.K., Coiro, J., Castek, J., & Henry, L.A. (2019). New Literacies: A dual level theory of the changing nature of literacy, instruction, and assessment. In D. E. Alvermann, N. J. Unrau, M. Sailors, & R. B. Ruddell (Eds.), *Theoretical models and processes of literacy* (7th ed., pp. 319–346). Taylor & Francis. https://doi.org/10.4324/9781315110592

Lewandowski, D., & Kammerer, Y. (2020). Factors influencing viewing behaviour on search engine results pages: a review of eye-tracking research. *Behaviour & Information Technology*, 1–31, https://doi.org/10.1080/0144929X.2020.1761450

Li, C. H. (2016). Confirmatory factor analysis with ordinal data: Comparing robust maximum likelihood and diagonally weighted least squares. *Behavior Research Methods*, *48*, 936–949. https://doi.org/10.3758/s13428-015-0619-7

Lindeman, J. (1998). *Ala-asteen lukutesti ALLU [Reading test for primary school ALLU]*. Center for Learning Research.

List, A., & Alexander, P. A. (2017). Analyzing and integrating models of multiple text comprehension. *Educational Psychologist*, *52*(3), 143–147. https://doi.org/10.1080/00461520.2017.1328309

List, A., & Alexander, P. A. (2019). Toward an integrated framework of multiple text use. *Educational Psychologist*, *54*(1), 20–39. https://doi.org/10.1080/00461520.2018.1505514

Lupo, S., Jang, B. G., & McKenna, M. (2017). The relationship between reading achievement and attitudes toward print and digital texts in adolescent readers. *Literacy Research: Theory, Method, and Practice*, *66*(1), 264–278. https://doi.org/10.1177/2381336917719254

Lyon, G. R., Shaywitz, S. E., & Shaywitz, B. A. (2003). A definition of dyslexia. *Annals of Dyslexia*, *53*(1), 1–14. https://doi.org/10.1007/s11881-003-0001-9

Macedo-Rouet, M., Braasch, J. L., Britt, M. A., & Rouet, J. F. (2013). Teaching fourth and fifth graders to evaluate information sources during text comprehension. *Cognition and Instruction*, *31*(2), 204–226. https://doi.org/10.1080/07370008.2013.769995

Macedo-Rouet, M., Potocki, A., Scharrer, L., Ros, C., Stadtler, M., Salmerón, L., & Rouet, J. F. (2019). How good is this page? Benefits and limits of prompting on adolescents' evaluation of web information quality. *Reading Research Quarterly*, *54*(3), 299–321. https://doi.org/10.1002/rrq.241

Mäkikangas, A., Tolvanen, A., Aunola, K., Feldt, T., Mauno, S., & Kinnunen, U. (2018). Multilevel latent profile analysis with covariates: Identifying job characteristics profiles in hierarchical data as an example. *Organizational Research Methods*, *21*(4), 931–954. https://doi.org/10.1177/1094428118760690

McKenna, M. C., Conradi, K., Lawrence, C., Jang, B. G., & Meyer, J. P. (2012). Reading attitudes of middle school students: Results of a US survey. *Reading Research Quarterly*, *47*(3), 283–306. https://doi.org/10.1002/rrq.021

McNamara, D. S., Roscoe, R., Allen, L., Balyan, R., & McCarthy, K. S. (2019). Literacy: From the perspective of text and discourse theory. *Journal of Language and Education*, *5*(3), 56–69 https://doi.org/10.17323/jle.2019.10196

Meyer, J. P., & Morin, A. J. (2016). A person-centered approach to commitment research: Theory, research, and methodology. *Journal of Organizational Behavior*, *37*(4), 584–612. https://doi.org/10.1002/job.2085

Miller, A. C., Keenan, J. M., Betjemann, R. S., Willcutt, E. G., Pennington, B. F., & Olson, R. K. (2013). Reading comprehension in children with ADHD: Cognitive underpinnings of the centrality deficit. *Journal of Abnormal Child Psychology*, *41*(3), 473–483. https://doi.org/10.1007/s10802-012-9686-8

Mirsky, A. F., Pascualvaca, D. M., Duncan, C. C., & French, L. M. (1999). A model of attention and its relation to ADHD. *Mental Retardation and Developmental Disabilities Research Reviews*, *5*(3), 169–176. https://doi.org/10.1002/(SICI)1098-2779(1999)5:3%3C169:AID-MRDD2%3E3.0.CO;2-K

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, *41*(1), 49–100. https://doi.org/10.1006/cogp.1999.0734

Mol, S. E., & Bus, A. G. (2011). To read or not to read: A meta-analysis of print exposure from infancy to early adulthood. *Psychological Bulletin*, *137*(2), 267–296. https://doi.org/10.1037/a0021890

Moll, K., Snowling, M. J., & Hulme, C. (2020). Introduction to the special issue "comorbidities between reading disorders and other developmental disorders". *Scientific Studies of Reading*, *24*, 1–6. https://doi.org/10.1080/10888438.2019.1702045

Muthén, L. K., & Muthén, B. O. (1998–2017). *Mplus user's guide* (8th ed.). Muthén & Muthén.

Naumann, J. (2015). A model of online reading engagement: Linking engagement, navigation, and performance in digital reading. *Computers in Human Behavior*, *53*, 263–277. https://doi.org/10.1016/j.chb.2015.06.051

Nylund, K. L., Asparouhov, T., & Muthén, B. O. (2007). Deciding on the number of classes in latent class analysis and growth mixture modeling: A Monte Carlo simulation study. *Structural Equation Modeling: A Multidisciplinary Journal*, *14*(4), 535–569. https://doi.org/10.1080/10705510701575396

Pennington, B. F., Santerre-Lemmon, L., Rosenberg, J., MacDonald, B., Boada, R., Friend, A., Leopold, D. R., Samuelsson, S., Byrne, B., Willcutt, E. G., & Olson, R. K. (2012). Individual prediction of dyslexia by single versus multiple deficit models. *Journal of Abnormal Psychology*, *121*(1), 212–224. https://doi.org/10.1037/a0025823

Pérez, A., Potocki, A., Stadtler, M., Macedo-Rouet, M., Paul, J., Salmerón, L., & Rouet, J. F. (2018). Fostering teenagers' assessment of information reliability: Effects of a classroom intervention focused on critical source dimensions. *Learning and Instruction*, *58*, 53–64. https://doi.org/10.1016/j.learninstruc.2018.04.006

Perfetti, C., & Stafura, J. (2014). Word knowledge in a theory of reading comprehension. *Scientific Studies of Reading*, *18*, 22–37. https://doi.org/10.1080/10888438.2013.827687

Peugh, J., & Fan, X. (2013). Modeling unobserved heterogeneity using latent profile analysis: A Monte Carlo simulation. *Structural Equation Modeling: A Multidisciplinary Journal*, *20*(4), 616–639. https://doi.org/10.1080/10705511.2013.824780

Pfost, M., Dörfler, T., & Artelt, C. (2013). Students' extracurricular reading behavior and the development of vocabulary and reading comprehension. *Learning and Individual Differences*, *26*, 89–102. https://doi.org/10.1016/j.lindif.2013.04.008

Primor, L., & Katzir, T. (2018). Measuring multiple text integration: A review. *Frontiers in Psychology*, *9*, 2294. https://doi.org/10.3389/fpsyg.2018.02294

Pulkkinen, J., Räikkönen, E., Jahnukainen, M., & Pirttimaa, R. (2020). How do educational reforms change the share of students in special education? Trends in special education in Finland. *European Educational Research Journal*, *19*(4), 364–384. https://doi.org/10.1177/1474904119892734

Reis, A., Araújo, S., Morais, I. S., & Faísca, L. (2020). Reading and reading-related skills in adults with dyslexia from different orthographic systems: A review and meta-analysis. *Annals of Dyslexia*, *70*(3), 339–368. https://doi.org/10.1007/s11881-020-00205-x

Rouet, J. (2006). *The skills of document use: From text comprehension to web-based learning*. Lawrence Erlbaum.

Salmerón, L., García, A., & Vidal-Abarca, E. (2018). The development of adolescents' comprehension-based internet reading skills. *Learning and Individual Differences*, *61*, 31–39. https://doi.org/10.1016/j.lindif.2017.11.006

Savalei, V., Reise, S.P., Vazire, S., & Fried, E. (2019). Don't forget the model in your model-based reliability coefficients: A reply to McNeish (2018). *Collabra: Psychology*, *5*(1). https://doi.org/10.1525/collabra.247

Schiefele, U., Schaffner, E., Möller, J., & Wigfield, A. (2012). Dimensions of reading motivation and their relation to reading behavior and competence. *Reading Research Quarterly*, *47*(4), 427–463. https://doi.org/10.1002/RRQ.030

Shaywitz, B. A., Fletcher, J. M., & Shaywitz, S. E. (1995). Defining and classifying learning disabilities and attention-deficit/hyperactivity disorder. *Journal of Child Neurology*, *10*, S50–S57. https://doi.org/10.1177/08830738950100S111

Snowling, M. J., & Melby-Lervåg, M. (2016). Oral language deficits in familial dyslexia: A meta-analysis and review. *Psychological Bulletin*, *142*(5), 498–545. https://doi.org/10.1037/bul0000037

Spear-Swerling, L., Brucker, P. O., & Alfano, M. P. (2010). Relationships between sixth-graders' reading comprehension and two different measures of print exposure. *Reading and Writing*, *23*(1), 73–96. https://doi.org/10.1007/s11145-008-9152-8

Stadtler, M., & Bromme, R. (2014). The content–source integration model: A taxonomic description of how readers comprehend conflicting scientific information. In D. N. Rapp & J. L. G. Braasch (Eds.), *Processing inaccurate information: Theoretical and applied perspectives from cognitive science and the educational sciences* (pp. 379–402). The MIT Press.

Stanovich, K. E., & West, R. F. (1989). Exposure to print and orthographic processing. *Reading Research Quarterly*, *24*(4), 402–433. https://doi.org/10.2307/747605

The Finnish National Board of Education. (2004). *National core curriculum for basic education 2004*. The Finnish National Board of Education.

Torppa, M., Lyytinen, P., Erskine, J., Eklund, K., & Lyytinen, H. (2010). Language development, literacy skills, and predictive connections to reading in Finnish children with and without familial risk for dyslexia. *Journal of Learning Disabilities*, *43*(4), 308–321. https://doi.org/10.1177/0022219410369096

Torppa, M., Niemi, P., Vasalampi, K., Lerkkanen, M. K., Tolvanen, A., & Poikkeus, A. M. (2020). Leisure reading (but not any kind) and reading comprehension support each other—A longitudinal study across grades 1 and 9. *Child Development*, *91*(3), 876–900. https://doi.org/10.1111/cdev.13241

van Deursen, A. J. A. M., & van Diepen, S. (2013). Information and strategic Internet skills of secondary students: A performance test. *Computers & Education*, *63*, 218–226. https://doi.org/10.1016/j.compedu.2012.12.007

van Strien, J. L., Brand-Gruwel, S., & Boshuizen, H. P. (2014). Dealing with conflicting information from multiple nonlinear texts: Effects of prior attitudes. *Computers in Human Behavior*, *32*, 101–111. https://doi.org/10.1016/j.chb.2013.11.021

Vellutino, F. R., Fletcher, J. M., Snowling, M. J., & Scanlon, D. M. (2004). Specific reading disability (dyslexia): What have we learned in the past four decades? *Journal of Child Psychology and Psychiatry*, *45*(1), 2–40. https://doi.org/10.1046/j.0021-9630.2003.00305.x

Walhout, J., Oomen, P., Jarodzka, H., & Brand-Gruwel, S. (2017). Effects of task complexity on online search behavior of adolescents. *Journal of the Association for Information Science and Technology*, *68*(6), 1449–1461. https://doi.org/10.1002/asi.23782

Willcutt, E. G., Betjemann, R. S., Pennington, B. F., Olson, R. K., DeFries, J. C., & Wadsworth, S. J. (2007). Longitudinal study of reading disability and attention-deficit/hyperactivity disorder: Implications for education. *Mind, Brain, and Education*, *1*(4), 181–192. https://doi.org/10.1111/j.1751-228X.2007.00019.x

Willcutt, E. G., & Pennington, B. F. (2000). Comorbidity of reading disability and attention-deficit/hyperactivity disorder: Differences by gender and subtype. *Journal of Learning Disabilities*, *33*(2), 179–191. https://doi.org/10.1177/002221940003300206

Willcutt, E. G., Pennington, B. F., Olson, R. K., Chhabildas, N., & Hulslander, J. (2005). Neuropsychological analyses of comorbidity between reading disability and attention deficit hyperactivity disorder: In search of the common deficit. *Developmental Neuropsychology*, *27*(1), 35–78. https://doi.org/10.1207/s15326942dn2701_3

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APPENDIX A

Comparison of Nested Online Research and Comprehension Measurement Models

Model Fit Statistics	Four-Factor Model	Five-Factor Model	Six-Factor Model	Chi-Square Difference Tests
$\chi^{2\text{-test}}$ (*df*)	172.20 (84)	143.15 (80)	83.57 (75)	
	$p < .001$	$p < .001$	$p = .233$	
$\chi^{2\text{-diff-test}}$ (*df*)				
Four-Factor Model vs. Five-Factor Model				23.60 (4); $p < .001$
Five-Factor Model vs. Six-Factor Model				43.08 (5); $p < .001$
RMSEA	.05	.04	.02	
CFI	.97	.98	1.00	
TLI	.96	.97	1.00	

Note. The factor loading structures of these three measurement models are presented in our previous work Kiili et al. (2018).

APPENDIX B

Correlation Matrix of Online Research and Comprehension Factor Scores and Reading Habit Variables

	Books	Newspapers	Magazines	Comics	Ebooks	Online Newspapers	Websites	Blog Posts	Forums
Locating Information	.16**	.03	.05	−.01	.09	.10*	.13**	.08	.05
Confirming the Credibility of Information	.30**	.07	.06	.08	.09	.02	.14**	.13**	.06
Questioning the Credibility of Information	.27**	.11*	.07	.11*	.06	.01	.10*	.04	.03
Identifying Main Ideas from a Single Online Text	.33**	.07	.09	.01	.07	.03	.14**	.17**	.05
Synthesizing Information Across Multiple Online Texts	.27**	.05	.12*	−.01	.09	.04	.15**	.23**	.06
Communicating Information	.32**	.04	.15**	.05	.11*	.04	.16**	.21**	.06

*Correlation is significant at the 0.05 level (2-tailed).
**Correlation is significant at the 0.01 level (2-tailed).

APPENDIX C

The 95% Confidence Intervals of Each Profile Groups' Mean Scores in the Six Online Research and Comprehension Component Skills