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Self-Regulatory Metacognitive Skill Use in Elementary Students During Computer and Paper Reading Assignments: A Qualitative Study

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Abstract

Self-regulated learning (SRL) and metacognitive processes are important in education because they contribute to effective learning and improved academic performance. Metacognitive SRL may be facilitated by the implementation of computer technology. This qualitative study examined the presence and use of metacognitive SLR processes among elementary school students as they completed computer- and paper-based reading assignments. Students in two after-school programs were recruited from a public school district in a southeastern region of the United States (U.S.). The participants consisted of 52 elementary students in Grades 2-5. Students participated in two, counterbalanced, conditions that involved computer- and paper-based reading assignments. Observations and semi-structured interviews were conducted. The results indicated that students were more likely to apply metacognitive SRL skills when reading on paper than reading on a computer. Overall, students showed signs of *planning* more in the paper than in the computer condition but student behaviors and responses differed between grades. *Monitoring* practices appeared in both the computer- and the paper-based reading assignment, with monitoring connected with background knowledge in Grades 2 and 3 but reading content in Grades 4 and 5. *Control* processes such as retrying and representing graphically were more common in the computer- than in the paper-based reading across all grades. Students used their score in a reading assignment as an *evaluation* tool to assess performance in the computer- and paper-based reading condition. These findings suggest that the utilization of prior information, integration of multimedia and verbal signals, and comfort level with the reading medium all influenced students' SRL decision-making.

Keywords:
Self-Regulated Learning, Metacognition, Online Reading, Elementary Grades

Introduction

Investments in education that are tied to computer technology in classrooms have increased recently (Gray & Lewis, 2021; Smith, 2016). Due to these initiatives, one computer per student is now virtually universally used (The White House, 2021; U.S. Department of Education, 2016; Zheng et al., 2016). The use of computers in the classroom enhances teaching and learning. In the domain of reading, computer technology is widely used. Studies have shown that digital reading can contribute to the development of language skills (Mayer, 2003; Xu et al., 2021), foster active learning (Dalgarno & Lee, 2010; Fiorella & Mayer, 2016; Robinson, 2016), and increase interest (Schiavo et al., 2021). Yet, such challenges as adaptive learning, prolonged engagement, task processing stemmed from digital modalities exist (Greenhow et al., 2022; Máñez et al., 2022). Also, variation in reading comprehension between grades and digital and print media (Clinton, 2019; Furenes et al., 2021), differences in achievement scores (Gulek & Demirtas, 2005; Mora et al., 2018), but also in higher-order thinking have been reported (Combrinck & Mtsatse, 2019; Earle et al., 2020). Despite the growing popularity of computer technology in education, there is limited evidence that primary school students use higher-order cognitive skills for text comprehension in their typical classroom and computer lab environments. Incorporating self-reflections and learning strategies into computer-based classrooms implies that learners would have to assess the thought process behind their conclusions; this process is known as metacognitive SRL. The current qualitative study attempts to fill this gap by providing naturalistic accounts of students' completing computer- and paper-based reading assignments. The findings may provide insights into ways elementary students apply SRL metacognitive processes and may have implications for instruction and educational technology.

The Interplay of Self-Regulated Learning and Computer Use

Planning, monitoring, control strategies, and evaluation are all part of the SRL metacognitive processes (Bandura, 1991; Pintrich & de Groot, 1990; Schunk, 2008). Planning is the process of thinking strategically and taking proactive steps to achieve a learning objective (Corno, 1994; Greene et al., 2010). Monitoring is the cognitive response that propels learning objectives while controlling thought and behavior (Brown, 1977; Pintrich, 1999). Metacognitive SRL entails active control and corrective actions, as well as learning tactics like concept organization, close reading, reading aloud, and retrying (Flavell, 1979). Evaluation involves the performance mechanism by which a learner assesses if the desired goals have been met (Koriat, 2012; Manlove et al., 2007; Zimmerman, 1989).

Examining SRL metacognitive indicators can help us understand the ways scaffolding, modeling, feedback, and interactivity assist students while engaging in computer tasks (Bannert et al., 2015; Serrano et al., 2018; Sha et al., 2012). Researchers have suggested that the integration of computer technology in education is important as computers can encourage the transfer of prior knowledge (Bulu & Pedersen, 2012; Muis et al., 2015; Price & Oliver, 2007). Notable effects using computers in education have been reported in relation to memory gains and attention (Chevalère et al., 2021; Schacter & Szpunar, 2015); use of higher-order executive skills for goal attainment (Al-Jarrah et al., 2018); problem-solving development in middle-school students (Muis et al., 2016; Postholm, 2011), and in high-school students metacognitive SRL during online courses and in math-learning software (Dresel & Haugwitz, 2008; Lin et al., 2017). Conversely, digital reading may produce taxed working memory and cognitive load (Paans et al., 2018; Pratt & Martin, 2017), miscalibration between perceived and actual accuracy in performance tests (Pilegard & Fiorella, 2016), or boredom and frustration that may cause distraction in goal achievement (Artino, 2009). In summary, metacognitive SRL develops during the middle-school years and involves the ability to make autonomous learning choices, to adapt goals to new circumstances, and modify responses after receiving positive or negative feedback.

Self-Regulated Learning and Computer- versus Paper-Based Reading

In the present study, we attempt to shed light on students's reading comprehension. The process of learning entails coming to conclusions through self-reflection and self-regulatory strategies (Groß, 2021); these processes are also essential in reading comprehension (Earle et al., 2020; Qi, 2021). The most appropriate way for students to extract meaning during reading is through conscious and controlled use of reading strategies, which requires a degree of metacognitive skills (Koutsouraki, 2020; Pressley & Afflerbach, 1995). Notably, reading comprehension is associated with increased SRL practices (C.-M. Chen et al., 2019; Q.-S. Chen, 2009). Scaffolded supports have been positively associated with SRL processes and metacognitive strategies in computer-based educational environments (Serrano et al., 2018; Vidal-Abarca et al., 2010). Past research has demonstrated that scaffolding strategies in online environments can boost the metacognitive skills of sixth graders, and these skills depend upon the use of prior knowledge in upper-grade students (Bulu & Pedersen, 2012; Roussel, 2011). But, in a meta-analysis of 54 studies between 2000-2017, Delgado et al. (2018) compared print and digital reading for children and adults and pinpointed a digital inferiority of the computer medium in fostering reading comprehension and

learning tasks. Furthermore, Clinton (2019) conducted a meta-analysis on 33 studies that examined paper versus screen reading for children and adults during a decade, 2008-2018. Their findings suggested that paper reading constituted a more efficient way to comprehend the material and improve test performance than screen reading. Furenes et al. (2021) also meta-analyzed findings from 39 studies that focused on paper and digital reading in children ages 1 to 8 years old. Their findings corroborated previous results that showed lower comprehension rates of digital than paper reading. However, the authors professed that digital reading that contained visual and story vocabulary cues outperformed paper reading. And, Latini and Bråten (2022) researched a sample of 116 Norwegian undergraduate students in relation to reading informational texts on a tablet versus paper. The results did not favor the hypothesis of paper offering comprehension advantages. In fact, there were no differences between the two media in terms of metacognitive cognitive and behavioral activities during text processing. Therefore, examining metacognitive SRL practices of elementary students in computer-based versus paper-and-pen reading tasks can advance our knowledge-base regarding differences in development and impact of the reading medium.

From a methodological perspective, observations and in-depth interviews can produce deep explorations of SRL metacognitive practices in computer-supported learning (Ferreira et al., 2017; Postholm, 2011; Robson, 2016). Past qualitative approaches to examining computer-based SRL include: (a) discourse analysis of virtual learning interactive communities where a reconciliation of individualized with collaborative learning was enacted (Delfino, et al., 2008); (b) triangulation of interviews from elementary and middle school students, teachers, and administrators which revealed positive correlations between personalized computer learning and persistence in completing reading assignments (Underwood & Banyard, 2008); (c) case study for primary school students where video-engaging recall produced fewer monitoring activities in reading (Pratt & Martin, 2017); (d) transcriptions of students' speaking aloud utterances demonstrating that student engaging in a hypermedia-learning environment contributed to deep-strategy use (Deekens et al., 2018). The current study extends previous qualitative research by incorporating natural accounts of elementary-aged students as they complete computer and paper-pen reading assignments.

Research Questions

This qualitative study had two research questions: (1) "Do elementary students demonstrate the use of SRL metacognitive processes during computer-based and paper-pencil reading tasks?"; and (2) "Are there apparent differences in the use of SRL metacognitive processes between the primary and upper elementary grades?"

Methods

Epistemological Paradigm

We applied the epistemology of constructivism to shed light and meaning into the reality of computer technology use in elementary education (Krauss, 2005; Guba & Lincoln, 1994). We conducted observations and semi-structured interviews to (a) record actions and utterances in a naturalistic educational setting; (b) gain a deeper level of detail by establishing rapport with each participant; and (c) eliminate dominating or distracting voices, thus allowing a variety of perspectives and ideas to surface. Observations and semi-structured interviews were conducted concurrently (Creswell & Plano Clark, 2010; McCrudden et al., 2019). Research assistance from trained undergraduate students contributed to the triangulation of methods and data and guarded against researcher bias (Tashakkori & Teddlie, 1998).

Recruitment

We recruited elementary students in Grades 2-5 from two after-school programs in a southeastern U.S. school district. The first program was fee-based, served students from pre-K to grade 5 operated 5 days a week during the school year, and provided recreational and enrichment activities. The second after-school program was funded through the 21st Century Community Learning Centers program, served students from Kindergarten to grade 5, operated 3 days a week, and emphasized academic tutoring. The after-school programs gave us access to elementary students during non-school hours, thus affording us uninterruption of regular instruction. The study was approved by the school district and the university's IRB. We invited 156 parents, and 69 agreed to have their children participate (42% return rate). Out of 69 consented students, data collection produced 52 accounts and concluded in spring 2020 when the COVID-19 lockdown forced the suspension of all school activities.

Sample

The 52 students were from 32 different classrooms with different teachers. The final sample size was acceptable for achieving saturation for the underlined theoretical associations (Baker & Edwards, 2012; Saunders et al., 2018). Saturation was achieved when codes, themes, and theoretical components were repeated, and no new elements of relevance were revealed through additional data (Glaser & Strauss, 1967; Saunders et al., 2018). Participants' age ranged

from 7 to 11 years-old (M = 9.06, SD = 1.21; 62% boys), and 29% were African-American, 6% Asian-American, and 65% European-American. As an indicator of socioeconomic status (SES), we used participation in a free or reduced meal program. Among participants, 21% received free lunch, 4% received reduced lunch, and 75% paid for their lunch (Table 1).

Measures

To conduct observations and semi-structured interviews, we employed items from the Junior Metacognitive Awareness Inventory (Jr. MAI; Sperling et al., 2002) and the original MAI (Schraw & Dennison, 1994). The subscale regulation of cognition was used for assessing the following dimensions: planning (3 items – "think before I choose," "think of several ways," and "make side notes", including annotating and pointing at words with cursor or pencil); monitoring (2 items – "ask how well I am doing," and "check before moving on"); control-learning strategies (3 items – "draw diagrams," "pay attention to cues," and "read out aloud"); evaluation (4 items – "go over unclear information," "reread," "ask myself if I learned," and "know how well I did"). Items were adapted to reflect engagement with computer- and paper-and-pencil-based reading assignments. During the observation phase, we recorded SRL metacognitive behaviors and questions from participants and notes and memos from researchers. During the interview phase, we asked participants about their SRL metacognitive behaviors and cognitive processes using prompts and follow-up questions.

Procedures

Each student attended two sessions: Condition 1 – reading assignment using computer; and Condition 2 – reading assignment using paper and pencil. Sessions were separated by 7-15 days. The order of conditions was counterbalanced and randomly assigned across students; in each grade, about half of students first completed the computer condition and half the paper-pencil condition. Each participant was observed and interviewed alone. In both conditions, students completed a reading assignment in a classroom lab. Observations and interviews were conducted by the principal researcher with support from four undergraduate assistants, one per session. Assistants were blinded to each other's results and to principal researcher's. Reading tasks in the computer condition were assigned by students' teachers in their respective grade using the i-Ready online educational program which aligns with Common Core Standards (Curriculum Associates LLC., 2019). Two distinctive features of the online version of i-Ready are narration and feedback. Reading tasks in the paper-and-pencil iReady condition were assigned by the principal researcher. Students completed an i-Ready worksheet for reading based on curriculum and standards guidelines by the state Department of Education and the local school district for exemplar units and lessons for the academic year. Reading topics in each condition ranged from myths, fiction, and poetry, to scientific facts, narrative and expository texts. During each session, participants were observed for SRL metacognitive practices, think-aloud utterances, and questions. Then, the researchers conducted interviews with students about their SRL metacognitive behaviors. Each session of observation and interview lasted on average 30 minutes. Items from Jr. MAI and MAI were read to participants and sometimes rephrased for clarification. To describe students' reflections on SRL metacognitive processes and gain insights on direct and retrospective cognitive and behavioral practices,

Table 1

Demographic Profile of All Participating Students in Grades 2-5 (n = 52)

Demographic Profile	2nd grade Count (%)	3rd grade Count (%)	4th grade Count (%)	5th grade Count (%)	Total Count
Sex					
Boys	6 (67%)	9 (64%)	12 (71%)	5 (42%)	32
Girls	3 (33%)	5 (36%)	5 (29%)	7 (58%)	20
Race					
African-American	3 (33%)	5 (36%)	2 (12%)	5 (42%)	15
Asian-American	0 (0%)	0 (0%)	2 (12%)	1 (8%)	3
European-American	6 (67%)	9 (64%)	13 (76%)	6 (50%)	34
Free or Reduced Lunch					
Free	2 (22%)	3 (21%)	1 (6%)	5 (42%)	11
Reduced	0 (0%)	1 (7%)	1 (6%)	0 (0%)	2
Paid	7 (78%)	10 (72%)	15 (88%)	7 (58%)	39
Age Breakdown					
7 years	5 (56%)				5
8 years	4 (44%)	10 (71%)			14
9 years		4 (29%)	9 (53%)		13
10 years			8 (47%)	5 (42%)	13
11 years				7 (58%)	7

we asked follow-up, open-ended questions (e.g., "Why do you say that?", or "Could you tell me more about that?"). We recorded behaviors and thinking processes related to a specific reading assignment given during the session, as well as to a reading assignment typically given at school. Memos from the principal researcher and the undergraduate students were also included in the data.

Data Analysis

Qualitative analysis was conducted using the NVivo 12 software (QSR International, Melbourne, Australia). The data analysis involved the following stages: (a) listening to audio recordings and transcribing them; (b) reading transcripts to highlight comments or phrases representative of participants' perspectives; (c) clustering of highlighted statements into summaries for generating domains of meaning; (d) classifying data sources by type (e.g. semi-structured interviews, observation notes, researcher memos); (e) identifying sections corresponding to general concepts or themes; and (f) aligning original codes with key SRL metacognitive processes. Once all statements were coded, four major classifications (themes) emerged based on the theoretical framework of SRL and metacognition; these were planning, monitoring, control, and evaluation. Analyzing these data allowed for reflections on emerged themes and comparisons between the two conditions; these themes included sounding out, and distractions. The data were closely examined to create lists of codes. New codes were constantly compared to earlier codes, and final codes were integrated into the theoretical constructs used. As codes integrated into main themes, we checked for additional sub-codes and performed axial coding to further collapse the data (Miles & Huberman, 1994). In addition, we cross-referenced codes with all data sources (i.e., observations, interviews, and memos) to deeply explore the data. The primary analytic strategies used were thematic analysis and triangulation. The researchers reviewed coded sections and looked for emerging themes across data sources according to the constant comparative method (Corbin & Strauss, 1990; Glaser & Strauss, 1967). Then, the researchers checked for converging or conflicting findings by groups of participants and data collection method.

Trustworthiness and Authenticity

Triangulation of data (i.e., field observations, semi-structured interviews, and memos from multiple researchers) was employed to achieve transferability of conclusions and trustworthiness (Guba, 1981; Guba & Lincoln, 1994; Kornbluh, 2015). Credibility was ensured by instantaneous checking data accuracy as previously recommended (Shenton, 2004). To ensure dependability we examined the raw data in each condition and against the researchers' personal reflections in memos and in audit trails that evaluated the effectiveness of the qualitative inquiry and implementation. To ensure trustworthiness, we: (a) triangulated the sources; (b) employed multiple raters; (c) matched the data with pre-determined theoretical constructs and created additional codes for emerged themes; (d) engaged with the data through a prolonged analytic process and the writing of rich descriptions; and (e) applied member checking of behaviors observed in interviews. To ensure authenticity, we: (a) used original research objectives; (b) maintained a consistent demeanor when observing and interviewing students; (c) involved original and follow-up questions to account for evolving themes; (d) defined constructs with an operational codebook; (e) perfomed critical appraisal and interpretation of the data (Guba & Lincoln, 1994; Morrow, 2005; Yin, 2011).

Measures Against Researcher Bias

To protect against researcher bias, we treated students as active agents with their own voice (Howitt & Cramer, 2011). The principal researcher guided conversations using simple language and specific prompts. Moreover, students participated at their own free will in accordance with ethical research guidelines. Trustworthiness and credibility were safeguarded as described earlier. Finally, the researchers engaged in self-reflection and self-questioning using memos and personal comments to eliminate traces of implicit bias (Wilson, 1998).

Results

Next, we present our findings in each metacognitive SRL dimension, namely planning, monitoring, control, and evaluation processes.

Planning

In the computer condition, second and third grade students first read a passage in its entirety and looked for word definitions, then responded to questions. Students in Grades 3 and 4 pointed the cursor to words to direct eye-text movement. When asked, third graders replied that they intuitively used response elimination but they could not explain why. Statements from fourth grade students suggested a reliance on teacher instruction and an emphasis on specific vocabulary words as planning tactics. In general, students did not annotate on a separate piece of paper. Remarkably, third and fourth graders perceived annotations as "cheating" because of not using their "own brain" but an external aid. Fifth graders relied on computer characters for story narration or question citation, a tactic that resulted in responding without reading. However, fifth graders claimed that computer narration helped them comprehend word definitions and pronunciation and validate their own thinking process:

> *The text helps and the way that the computer character speak also helps me think about the way I say it [and] the way they say it. I kind of combine it together and I know how to say it. For the "Write" portion, I usually answer the question and then I know that since I've answered the question, let him [computer character] know what I'm talking about. And then I just use the rest of my own words.*

During the paper-based assignment, second graders finger- or pencil-pointed while reading, or numbered verses in poems. Third and fourth graders approached paper reading with a plan: some first checked all text boxes and passage in the worksheet, whereas others looked at all questions first and answered them second. In addition, third graders mentioned tangible elements for planning their reading in print (e.g., looking at title or identifying context clues, and then "circling the best response", or "eliminating at least half of those [responses] that might be wrong.") Fourth graders appeared influenced by the reading genre and paused to integrate previous learning before responding to questions. Unlike computer reading, fourth graders created annotations, especially for reading texts perceived as "hard." Finally, fifth grade students viewed reading passages in their entirety, pondered, and then started answering questions. They notably avoided annotations because they perceived them as "off-track" distracting activities.

Students across conditions and grades used a structural approach to reading and pointed either the computer cursor or pencil to focus and complete a reading assignment. However, we identified the following variations in planning between conditions: (a) fourth graders integrated prior knowledge for completion more in the paper than the computer condition; (b) third graders used more context clues in the paper than in computer condition; (c) third grade students applied the process of elimination in both conditions; (d) fourth graders made annotations in both conditions; and (e) fifth grade students listened to computer narration.

Monitoring

During the computer-based reading assignment, second grade students asked themselves questions and repeated difficult words to crystallize understanding. Another monitoring method was to ask the researchers questions about the writing segment of a reading assignment, or about the meaning or spelling of a word. Third graders used rechecking and rereading after receiving a bad grade in a test. Rereading prompted students to rely on computer character narration because it "helps to understand and get it right." Fifth graders, however, perceived computer character narration as confusing because it contradicted their prior knowledge. Those students talked to themselves to recall previously learned elements in the text and then continued reading to understand. Fourth and fifth graders commonly used computer feedback for monitoring and in revising responses:

> *"If I can't remember what I answered wrong, the program tells me when I answer a question wrong. When I don't understand it, I might read it a couple of times. And then, I might see if the computer will read it, just to clarify what it is."*

During the paper-based reading assignment, students either asked themselves or asked the researchers questions:

> *As a student read multiple choice options, he said "maybe" for the correct option. In the case of open-ended questions, the student repeated the phrase "which item supports the point" before he answered. The student tilted his head up and whispered, "what was I thinking about that?" After the student read options again, he posed a question by asking "so what was the question again?" [Researchers' observation notes for second grade students]*

Students focused on the meaning and pronunciation of challenging words while completing paper-based reading assignments. Students in Grades 2 and 3 verified responses upon teacher review. However, fourth graders said that "second-guessing" was a disadvantage and resulted in wrong responses "because a lot of times when I do that, I get it wrong when I [at first] had the right answer." Furthermore, most fourth and fifth graders were concerned with "how to do things" in completing open-ended questions, reading aloud, recording evidence from passages, or graphically representing meaning.

Overall, students demonstrated monitoring practices in both the computer- and paper-based reading assignments, i.e., asking questions, and rechecking answers. Monitoring was knowledge-based in Grades 2 and 3 meaning prior knowledge of content affected the process of monitoring. Conversely, monitoring was task-based in Grades 4 and 5, meaning familiarity with condition affected the process of monitoring. There were variations between conditions and grades in monitoring practices. Fourth and fifth grade students used computer-generated feedback to a greater extent than students in other grades. Third grade students used informational clues more in the paper than in the computer condition.

Sounding out

A sub-theme of monitoring documented more in the paper than in the computer condition, was "sounding out." According to students, "sounding out" meant piecing together a word from its syllables. In the computer-based assignment, "sounding out" occurred with computer-generated feedback. For second and third graders, "sounding words out" was a way to understand ambiguous reading elements and correctly complete the assignment. Fourth grade

students relied on the computer for pronunciation and meaning of unknown words: "if it's important, I'll click on [word] and [computer program] will have a speech thing. I'll see what it is and the definition of the word." However, fifth graders stated that when tried "sounding out" this strategy did not improve their comprehension.

Second, third, and fourth grade students retrospectively mentioned that, in the paper-based reading assignment, "sounding it out" helped them understand unknown or unclear words. Among second graders, "sounding out" words was not beneficial; however, for third grade students, sounding out helped "figure out what the answer is" and contributed to close reading strategies (e.g., rereading, reflecting). Fourth graders mentioned that examining the parts of a word aided in content comprehension of paper reading assignments: "I look at the beginning of the word and what that means, then I look at the end of the word, and then I figure out what the word means." Other fourth graders mentioned that "sounding out" was a multi-step process: "I'll cover up part of the words and say 'participation.' I'll cover up 'icipation' and I say, 'I know that word is 'part' and then I'll figure out the next part."

Control

Students demonstrated some control processes during computer-based reading, one of which was organizing information in charts and tables. Fourth and fifth grade students acknowledged that creating pictures or diagrams left mental traces that aided in remembering information. Yet, when asked, students across grades reported that tables/charts did not aid comprehension of computer reading assignments. Students in Grades 2 and 3 stated that information on sidebars and context clues assisted them with deciphering important information. Likewise, students in Grades 4 and 5 used information cues and "read it" buttons to review and understand computer-based reading passages. This helped students to "almost always get the questions right." Surprinsingly, computer read aloud tools assisted students with reading text.

During the paper-based reading assignments, students demonstrated some control processes. Table/chart creation was more challenging in the paper than the computer condition for early elementary students. Many of them did not understand how to do it and skipped parts of reading assignments. Fifth graders successfully created organizational charts but time restrictions prevented from completing them. In the paper condition, students used surface-level strategies, e.g., underlining or circling; this was mostly evident among second graders. Third graders tended to pause and ponder as they gradually completed the writing portion of paper reading assignments, whereas fourth graders read titles, bold words, and hint boxes. Response elimination (i.e., crossing out response choices and circling the correct or best response) was a prominent comprehension control strategy for fifth grade students. Reading aloud was hardly evident across students. Students in Grades 2 and 3 claimed that they did not want "to give away" their answers and attested that "reading in my head is more helpful" and this way "I would not interrupt the class." Other fourth graders seemed to associate reading aloud with an emotional state because "if I can't do it, it makes me more stressed out, and when I can read out loud, I can understand it while I have to process it in my head reading it." But with incorrect selections, voicing words silently and retrying were observed in third, fourth, and fifth graders.

Generally, students across grades were keener in retrying and organizing during computer than paper reading, but they performed close reading mostly in paper reading assignments. Reading aloud was barely documented in any of the two conditions, whereas the use of visual cues facilitated retrying in both conditions. During both the computer and paper conditions, visual elements seemed to mediate students' review and retry. Visual elements functioned as comprehension triggers to check learning. These features included checkmarks, smiley faces, and praise from animated characters in the computer condition, but bold words and informational text boxes in the paper condition. In both conditions, students in Grades 2, 3, and 4 stated that they had not been taught schematic representations of content. Most younger students could not recognize relationships, identify patterns, and establish connections in text. Nevertheless, computer embedded charts facilitated student learning because they made content easier to understand and remember. Yet, computer embedded charts discouraged students from creating charts on their own.

Distractions. A sub-theme of control that emerged was "distractions," and more so in computer than in paper reading. A form of distraction was eye regression – defined by Squire (2009) as the backward movement of the eye when reading. In our study, eye regression represented eye movement away from the text which seemed to interrupt SRL practices and independent learning. Eye regression was more evident in older than younger students. Second graders relied on computer character narration of text or questions and responses which contributed to eye regression. Fourth graders seemed to divert their attention from the computer screen and look elsewhere, or fidgeted with irrelevant objects (e.g., own glasses, headphone cord). Likewise, eye regression in fifth grade students resulted in performing no SRL practices and randomly responding without reading. Some third-grade students crossed hands or held their face in boredom in

response to lengthy passages and difficult vocabulary during the computer-based reading assignment. Students reported that completing computer reading assignments decreased concentration. However, older students perceived "distractions" as advantageous because they triggered them to seek assistance from teachers.

Evaluation

In computer-based reading, students used embedded features to evaluate their performance; however, there were small variations between grades. To check the accuracy of a response, students relied on interactive multimedia including "green highlighted text" or "confetti throws" for correct responses, or green "DONE" signs for completed responses. Furthermore, praise prompts such as "beautiful," "you got it," "good job," or "nice one" enabled second-grade students to evaluate their progress. Third graders evaluated their performance using their progress score: "because one time, I didn't check my answer, I did mostly move on to the question, but then I got a '71' because I didn't go back and now I'm starting to go back and see." Fourth and fifth graders used computer feedback for evaluation when reviewing responses. Other fourth graders clicked on different response options to hear them in a sentence and then proceed to selecting using "trial and error."

During paper-based reading, students evaluated their performance by returning to the text. Repetitive going back was evident in the writing portion of the assignment, especially for students in Grade 3 or higher. Third graders stated that new information necessitated to "look at words around it" for clarity. Fifth graders seemed to rely on memory skills because they checked back less often than students in earlier grades. There were no instant evaluation prompts in paper-based reading. Students across grades reported that they did not always know their progress on paper reading assignments, unless the teacher graded it instantly and marked it with "smiley faces."

Overall, students across grades used their progress score to assess their performance in the computer and paper condition. However, we recorded two major differences in evaluation between the two conditions. First, students reported that they received continuous feedback and an instantaneous score during computer-based reading, whereas teacher feedback and score were delayed during paper-based reading. A faster evaluation seemed to provide more opportunities for corrective actions in computer- than paper-based reading. The second difference was that students return to the text to review and evaluate their performance more often in the paper- than the computer-based reading assignment.

Summary of Qualitative Findings

Students across all grade levels demonstrated SRL metacognitive processes under both reading conditions, although primary grade students were more likely do so when reading on paper. Specifically, students showed more signs of planning in the paper than in the computer condition but student behaviors and responses differed between grades. Monitoring practices appeared in both the computer- and the paper-based reading assignment; monitoring relied on prior content knowledge in Grades 2 and 3 and reading medium in Grades 4 and 5. Control processes such as retrying and organizing were more common in the computer- than in the paper-based reading. Close reading habits appeared more in paper than in computer reading, whereas distractions influenced control strategies more in computer- than in paper-based reading. Students used their progress score for evaluation of performance in both conditions.

Figure 1 highlights the main ideas associated with SRL metacognitive dimensions in the computer- and paper-based reading conditions.

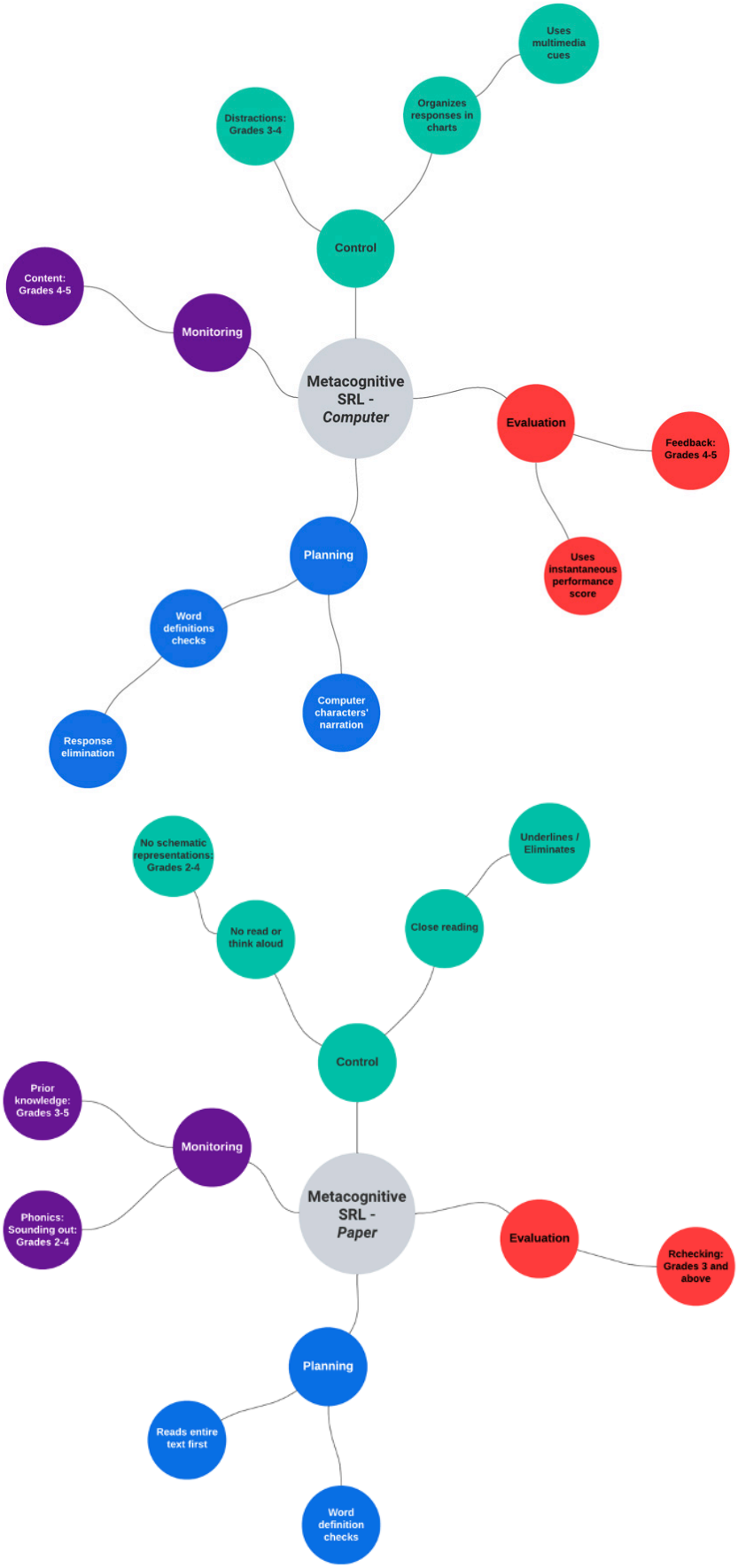
Discussion

The present qualitative study examined if elementary students in Grades 2-5 demonstrate SRL metacognitive processes during computer- and paper-based reading comprehension tasks and whether differences in SRL decision-making between conditions exist across grade levels. We documented that while students across all grade levels demonstrated SRL metacognitive processes under both conditions, strategy selection varied by grade level, and was overall more prevalent during paper-based reading.

The elementary students of the present sample regulated cognition by applying more types of planning and control processes in the paper than in the computer condition, and by demonstrating monitoring and evaluation processes in both conditions. Previous research has consistently shown the effects of planning to be present in older students (middle, high school, and undergraduate students) during both computer- and paper-based reading assignments (Follmer & Sperling, 2019; Manlove et al., 2007). Elementary students, however, have not been found to use planning processes when using electronic media (Muis et al., 2016), which may be attributed to differences in task and medium. Complementing this research, our results suggest that students apply planning to purposefully set learning goals and use strategies for attaining these goals. This finding is demonstrated more so in paper- than computer-based reading assignments because students may be more accustomed with organizing their learning and completing reading assignments in paper format (Greene et al., 2010; Kuisma & Nokelainen, 2018).

Figure 1

Main Findings of Metacognitive SRL Processes Between Computer and Paper Reading Assignments in Grades 2-5



Students in our study demonstrated specific judgements that lead to monitoring practices in both computer and paper reading such as going back to the text in accordance with previous research in high school students (Hardcastle et al., 2017). Also, the present students engaged in the control strategy of close reading more in the paper than in the computer condition likely because they seemed to understand the presented features better during paper- than computer-based reading, which is consistent with past findings in middle and high school students (Kim & Kim, 2013; Stoop et al., 2013). Furthermore, we saw that students paid attention to visual and context clues to monitor reading deficiencies and apply learning strategies. However, previous studies found more difficulty in the comprehension of text in screen/computer-based reading, which could also lead to more need for SRL strategies during monitoring and control (Clinton, 2019; Delgado et al., 2018; Furenes et al., 2021; Latini & Bråten, 2022). Similarly, standards of coherence could play a role in the strategies that are used. Collectively, the present results indicate that students shift their focus from "learning to read" in Grades 2 and 3 to "reading to learn" in Grades 4 and 5.

We also found that computer reading posed greater distractions than paper reading (e.g., computer characters), which may interfere with control strategies, as others have shown (Panadero, 2017; Salmerón et al., 2021; Storz & Hoffman, 2013). Detrimental effects on reading metacomprehension have been recorded in fifth grade students who use computers (Halamish & Elbaz, 2020), but positive metacognitive effects have been documented in third to fifth grade students who read e-books (Connor et al., 2019). Our findings showed that younger students were more attentive than older students which could be attributed to the nature and content of the reading assignment. In our computer assignment, the stimulating cues and animated characters were simpler in earlier grades but more complex in later grades. This may produce a cognitive load that disables monitoring and control in older students. It is therefore possible that teacher's instruction can aid students in differentiating between those features that promote versus those that impede SRL metacognitive strategies during computer-based reading assignments.

Two findings worth discussing are representation of text in tables and phonic exercises. First, students across grades used embedded charts and tables to transfer content in computer-based reading, but they did not graphically represent content in paper-based reading, with the exception of fifth graders who did. Organizing text graphically aids memorization and comprehension (Ponce et al., 2013; Zimmerman & Martinez Pons, 1986). Our study showed that graphic organizers may contribute to retention but the ability to comprehend was not reported, a finding that contradicts previous research on reading in print (Ackerman & Leiser, 2014; Crooks & Cheon, 2013; Schwartz et al., 1998). A possible explanation for the differences between our findings and those of previous studies is that younger students have not yet learned to recognize patterns in content and meaning, whereas older students have. We suggest that transfer of knowledge (e.g., the ability to graphically organize text) has not been achieved equally well for the two reading formats which may instigate modeling strategies and think alouds from teachers.

Second, students used the phonic approach of sounding words out more in the paper than in the computer condition. However, sounding-out did not yield the desired result (i.e., monitoring comprehension) among students in early grades which is in agreement with previous literature showing that younger students may still be in the process of understanding language conventions (Paris & Flukes, 2005; Ceyhan & Yildiz, 2021). Older students understood which reading comprehension processes were appopriate for paper assignments, but for computer assignments older students relied on electronic characters for phonological processing and phoneme awareness. In fact, the computer medium hindered sounding out, read aloud, and subsequent reading comprehension for students across grades, which is a novel finding in the literature of computer-assisted learning and metacognition. A possible explanation is that students have pobably not received instruction on how to transfer phonic exercises to computer reading assignments. Also, when students had the story narrated to them during the computer condition, this would mean that they were no longer reading which could have influenced the processes involved. Future research should address shortcomings of educational software design and ways teachers could overcome them in eliciting student comprehension and learning.

Finally, students used their performance to evaluate their progress in reading assignments, whether on computer or paper. Our findings in the computer condition showed that our participants received direct and explicit feedback that provided opportunities for students to recheck and correct a response, as past research has shown (Andrade, 2019; Azevedo & Hadwin, 2005; Manlove et al., 2007). This finding may be explained by the fact that computer-based feedback promotes persistence in successfully completing reading assignments. However, multiple rechecking and recalling of information was demonstrated more in the paper- than in the computer-based reading assignments. One possible explanation is that the computer software does not allow students to frequently recheck and revise, whereas the paper worksheet does. These findings suggest that education professionals and software developers should consider equivalent features for

elementary students evaluating, rechecking, and correcting their reading assignments.

Taken together the present and past findings indicate that planning, monitoring, control, and evaluation develop during the elementary school years, and this is slightly more evident in paper- than in computer-based reading assignments.

Implications

Our findings have implications for theory and practice. Our results expand the theoretical perspectives of SRL and metacognition. In this study, elementary grade students exposed to computer-based reading tasks show emerging traits of self-regulation and metacognition as early as second grade, along with increased strategy use and flexibility in the upper elementary grades. The multidimensional aspect of metacognition is comprised of interconnected thought processes and regulatory skills, such as planning, monitoring, and evaluating that motivate learners and improve academic performance (Brown et al., 1981; Flavell, 1979; Pintrich & de Groot, 1990). It appears that elementary students have the potential to apply regulatory metacognitive strategies between reading media.

From a practical standpoint, our results indicate that elementary-aged students can use metacognitive SRL strategies to help themselves complete computer-based reading tasks effectively. Planning, monitoring, control, and evaluation are ways to restore deficiencies in reading while performing computer- and paper-based reading assignments, across grades. However, computer-based reading software can contain confounding features, of which educators need to be aware. For example, the gradual appearance of a passage or feedback from animated characters tends to hinder SRL practices. These elements may interrupt SRL thought process and actions and disable students' own SRL capabilities. Students in computer-based reading assignments can receive instruction to set goals, ask themselves questions, read aloud, perform decoding and phonemic exercises without relying on computer characters that strip independent learning. Students in both conditions can improve cognitive deficiencies by cultivating cognitive schemas (memory, attention) that facilitate connections with different reading genres. Schematic representations using graphic organizers can potentially contribute to forming cognitive connections and applying SRL strategies. Likewise, modeling, and scaffolded instruction can focus on the process of acquiring SRL skills especially in low-stake and non-graded reading assignments. Finally, students across grades can collaborate during computer- and paper-based reading assignments in ways that promote knowledge sharing, peer interaction, and motivate high- and low-skill readers.

Limitations and Strengths

This research had limitations that should be considered. The sample included students from a single school district in a rural area and may not be fully representative of elementary students across the United States. There was unequal gender and grade distribution in the sample due to the school lockdown associated with the COVID-19 crisis. Finally, younger students seemed unfamiliar with the terminology of metacognitive SRL which we overcame by rephrasing question items. This practice, however, may have produced more thorough descriptions of SRL metacognitive processes in younger and older elementary-aged students.

The research also had strengths. Students served as controls of themselves and there was counterbalancing in the presentation of computer- and paper-based reading, which increases confidence that we identified true differences between conditions. Participants were observed and interviewed in a naturalistic setting with typical computer-based and paper-pen reading assignments. We generated in-depth findings by applying triangulation of methods and researchers. Finally, this is one of few studies where direct comparisons in metacognitive SRL processes were made between two popular reading modalities – computer and paper.

Conclusions

According to the qualitative data presented, students in lower and upper elementary grades possess SRL metacognitive skills, which are more readily apparent when performing reading tasks on paper than in computer. The results may imply increased familiarity with reading on paper and use of prior knowledge in the paper condition. Teachers may use these important insights as opportunities to cultivate and transfer SRL metacognitive skills in elementary students between the two reading formats – computer and paper.

References

Ackerman, R., & Leiser, D. (2014). The effect of concrete supplements on metacognitive regulation during learning and open-book test taking. *British Journal of Educational Psychology*, *84*(2), 329–348. https://doi.org/10.1111/bjep.12021

Al-Jarrah, T. M., Mansor, N., Rashid, R. A., Bashir, I., & Al-Jarrah, J. M. (2018). EFL students' attitude toward using metacognitive strategies in writing. *English Language Teaching*, *11*(10), 162–171. https://doi.org/10.5539/elt.v11n10p162

Andrade, H. L. (2019). A critical review of research on student self-assessment. *Frontiers in Education*, *4*, 13. https://doi.org/10.3389/feduc.2019.00087

Azevedo, R., & Hadwin, A. F. (2005). Scaffolding self-regulated learning and metacognition – Implications for the design of computer-based scaffolds. *Instructional Science*, *33*(5–6), 367–379. https://doi.org/10.1007/s11251-005-1272-9

Baker, S., Elsie, & Edwards, R. (2012). *How many qualitative interviews is enough? Expert voices and early career reflections on sampling and cases in qualitative research* (pp. 1–42). National Centre for Research Methods (NCRM). http://eprints.ncrm.ac.uk/2273/4/how_many_interviews.pdf

Bandura, A. (1991). Social cognitive theory of self-regulation. *Organizational Behavior and Human Decision Processes*, *50*(2), 248–287. https://doi.org/10.1016/0749-5978(91)90022-L

Bannert, M., Sonnenberg, C., Mengelkamp, C., & Pieger, E. (2015). Short-and long-term effects of students' self-directed metacognitive prompts on navigation behavior and learning performance. *Computers in Human Behavior*, *52*, 293–306. https://doi.org/10.1016/j.chb.2015.05.038

Brown, A. L. (1977). *Knowing when, where, and how to remember: A problem of metacognition.* (Technical Report No. 47; Bolt, Beranek and Newman, Inc., Cambridge, Mass., p. 146). Center for the Study of Reading. https://eric.ed.gov/?id=ED146562

Brown, A. L., Campione, J. C., & Day, J. D. (1981). Learning to learn: On training students to learn from texts. *Educational Researcher*, *10*(2), 14–21. https://doi.org/10.3102/0013189X010002014

Bulu, S. T., & Pedersen, S. (2012). Supporting problem-solving performance in a hypermedia learning environment: The role of students' prior knowledge and metacognitive skills. *Computers in Human Behavior*, *28*(4), 1162–1169. https://doi.org/10.1016/j.chb.2012.01.026

Ceyhan, S., & Yildiz, M. (2021). The effect of interactive reading aloud on student reading comprehension, reading motivation and reading fluency. *International Electronic Journal of Elementary Education*, *13*(4), 421–431. https://doi.org/10.26822/iejee.2021.201

Chen, C.-M., Chen, L.-C., & Horng, W.-J. (2019). A collaborative reading annotation system with formative assessment and feedback mechanisms to promote digital reading performance. *Interactive Learning Environments*, 1–18. https://doi.org/10.1080/10494820.2019.1636091

Chen, Q.-S. (2009). Metacomprehension monitoring and regulation in reading comprehension. *Acta Psychologica Sinica*, *41*(8), 676–683. https://doi.org/10.3724/SP.J.1041.2009.00676

Chevalère, J., Cazenave, L., Berthon, M., Martinez, R., Mazenod, V., Borion, M. C., Pailler, D.,

Rocher, N., Cadet, R., Lenne, C., Maïonchi-Pino, N., & Huguet, P. (2021). Computer-assisted instruction versus inquiry-based learning: The importance of working memory capacity. *PLoS ONE*, *16*(11 November). https://doi.org/10.1371/journal.pone.0259664

Clinton, V. (2019). Reading from paper compared to screens: A systematic review and meta-analysis. *Journal of Research in Reading, 42*(2). https://doi.org/10.1111/1467-9817.12269

Combrinck, C., & Mtsatse, N. (2019). Reading on paper or reading digitally? Reflections and implications of ePIRLS 2016 in South Africa. *South African Journal of Education*, *39*. https://eric.ed.gov/?id=EJ1242907

Connor, C. M., Day, S. L., Zargar, E., Wood, T. S., Taylor, K. S., Jones, M. R., & Hwang, J. K. (2019). Building word knowledge, learning strategies, and metacognition with the Word-Knowledge e-Book. *Computers & Education*, *128*, 284–311. https://doi.org/10.1016/j.compedu.2018.09.016

Corbin, J., & Strauss, A. (1990). Grounded Theory Research: Procedures, Canons, and Evaluative Criteria. *Qualitative Sociology*, *13*(1), 1–20.

Corno, L. (1994). Implicit teachings and self-regulated learning. *Invited Address to Divisions K and C*, 52. https://eric.ed.gov/contentdelivery/servlet/ERICServlet?accno=ED377140

Creswell, J. W., & Plano Clark, V. L. (2010). *Designing and conducting mixed methods research* (2nd ed.). SAGE Publications, Inc.

Crooks, S. M., & Cheon, J. (2013). Strategies for note taking on computer-based graphic organizers. In G. Schraw, M. T. McCrudden, & D. Robinson (Eds.), *Learning through visual displays.* (2014-01969-008; pp. 187–221). IAP Information Age Publishing.

Curriculum Associates LLC. (2019). *Personalized learning for all students* [Education & Curriculum]. https://www.curriculumassociates.com/products/i-ready

Dalgarno, B., & Lee, M. J. W. (2010). What are the learning affordances of 3-D virtual environments? *British Journal of Educational Technology*, *41*(1), 10–32. https://doi.org/10.1111/j.1467-8535.2009.01038.x

Deekens, V. M., Greene, J. A., & Lobczowski, N. G. (2018). Monitoring and depth of strategy use in computer-based learning environments for science and history. *British Journal of Educational Psychology*, *88*(1), 63–79. https://doi.org/10.1111/bjep.12174

Delfino, M., Dettori, G., & Persico, D. (2008). Self-regulated learning in virtual communities. *Technology, Pedagogy & Education*, *17*(3), 195–205. https://doi.org/10.1080/14759390802383785

Delgado, P., Vargas, C., Ackerman, R., & Salmerón, L. (2018). Don't throw away your printed books: A meta-analysis on the effects of reading media on reading comprehension. *Educational Research Review* (Vol. 25), 23-38. https://doi.org/10.1016/j.edurev.2018.09.003

Dresel, M., & Haugwitz, M. (2008). A computer-based approach to fostering motivation and self-regulated learning. *Journal of Experimental Education*, *77*(1), 3–18. https://doi.org/10.3200/JEXE.77.1.3-20

Earle, F. S., Del Tufo, S. N., Evans, T. M., Lum, J. A. G., Cutting, L. E., & Ullman, M. T. (2020). Domain-general learning and memory substrates of reading acquisition. *Mind, Brain, and Education*, *14*(2), 176–186. https://doi.org/10.1111/mbe.12234

Ferreira, P. C., Simão, A. M. V., & da Silva, A. I. (2017). How and with what accuracy do children report self-regulated learning in contemporary EFL instructional settings? *European Journal of Psychology of Education*, *32*(4), 589–615. https://doi.org/10.1007/s10212-016-0313-x

Fiorella, L., & Mayer, R. E. (2016). Effects of observing the instructor draw diagrams on learning from multimedia messages. *Journal of Educational Psychology*, *108*(4), 528–546. https://doi.org/10.1037/edu0000065

Flavell, J., H. (1979). Metacognition and cognitive monitoring: A new area of cognitive—Developmental inquiry. *American Psychologist*, *34*(10), 906–911. https://doi.org/10.1037/0003-066X.34.10.906

Follmer, D. J., & Sperling, R. A. (2019). Examining the role of self-regulated learning microanalysis in the assessment of learners' regulation. *The Journal of Experimental Education*, *87*(2), 269–287. https://doi.org/10.1080/00220973.2017.1409184

Furenes, M. I., Kucirkova, N., & Bus, A. G. (2021). A comparison of children's reading on paper versus screen: A Meta-Analysis. *Review of Educational Research, 91*(4). https://doi.org/10.3102/0034654321998074

Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory; strategies for qualitative research*. Chicago: Aldine Pub. Co.

Gray, L., & Lewis, L. (2021). Use of educational technology for instruction in public schools: 2019-20. First look-summary. NCES 2021-017. *National Center for Education Statistics*.

Greene, J. A., Muis, K. R., & Pieschl, S. (2010). The role of epistemic beliefs in students' self-regulated learning with computer-based learning environments: Conceptual and methodological issues. *Educational Psychologist*, *45*(4), 245–257. https://doi.org/10.1080/00461520.2010.515932

Greenhow, C., Graham, C. R., & Koehler, M. J. (2022). Foundations of online learning: Challenges and opportunities. *Educational Psychologist*, *57*(3). https://doi.org/10.1080/00461520.2022.2090364

Groß, D. (2021). In the self-control and self-regulation maze: Integration and importance. *Personality and Individual Differences*, *175*, 110728. https://doi.org/10.1016/j.paid.2021.110728

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.). In *Handbook of qualitative research* (Vol. 2, p. 105). Thousand Oaks, Sage. http://steinhardtapps.es.its.nyu.edu/create/courses/3311/reading/10-guba_lincoln_94.pdf

Gulek, J. C., & Demirtas, H. (2005). Learning with technology: The impact of laptop use on student achievement. *Journal of Technology, Learning, and Assessment*, *3*(2), 1–39. https://ejournals.bc.edu/index.php/jtla/article/view/1655/1501

Halamish, V., & Elbaz, E. (2020). Children's reading comprehension and metacomprehension on screen versus on paper. *Computers & Education*, *145*, 103737. https://doi.org/10.1016/j.compedu.2019.103737

Hardcastle, J., Herrmann-Abell, C. F., & DeBoer, G. E. (2017). Comparing student performance on paper-and-pencil and computer-based-tests. *ScienceDaily*. https://www.sciencedaily.com/releases/2017/06/170612115723.htm

Howitt, D., & Cramer, D. (2011). *Introduction to research methods in psychology* (3rd ed). Prentice Hall/Pearson.

Kim, H., & Kim, J. (2013). Reading from a LCD monitor versus paper: Teenagers' reading performance. *International Journal of Research Studies in Educational Technology*, *2*(1), 15–24. https://doi.org/10.5861/ijrset.2012.170

Koriat, A. (2012). The relationships between monitoring, regulation and performance. *Learning and Instruction*, *22*(4), 296–298. https://doi.org/10.1016/j.learninstruc.2012.01.002

Kornbluh, M. (2015). Combatting challenges to establishing trustworthiness in qualitative research. *Qualitative Research in Psychology*, *12*(4), 397–414. https://doi.org/10.1080/14780887.2015.1021941

Koutsouraki, S. (2020). Metacognition and reading comprehension: Recent trends in theory, research and practice. *Psychology: The Journal of the Hellenic Psychological Society*, *16*(3), 205–225. https://doi.org/10.12681/psyhps.23815

Krauss, S. E. (2005). Research paradigms and meaning making: A primer. *The Qualitative Report*, *10*(4), 758–770. https://dx.doi.org/10.46743/2160-3715/2005.1831

Kuisma, M., & Nokelainen, P. (2018). Effects of progressive inquiry on cognitive and affective learning outcomes in adolescents' geography education. *Frontline Learning Research*, *6*(2), 1–19. eric. https://doi.org/10.14786/flr.v6i2.309

Latini, N., & Bråten, I. (2022). Strategic text processing across mediums: A verbal protocol study. *Reading Research Quarterly, 57*(2). https://doi.org/10.1002/rrq.418

Lin, C.-H., Zhang, Y., & Zheng, B. (2017). The roles of learning strategies and motivation in online language learning: A structural equation modeling analysis. *Computers & Education*, *113*, 75–85. https://doi.org/10.1016/j.compedu.2017.05.014

Máñez, I., Vidal-Abarca, E., & Magliano, J. P. (2022). Comprehension processes on question-answering activities: A think-aloud study. *Electronic Journal of Research in Educational Psychology*, *20*(56). https://doi.org/10.25115/ejrep.v20i56.3776

Manlove, S., Lazonder, A. W., & Jong, T. (2007). Software scaffolds to promote regulation during scientific inquiry learning. *Metacognition and Learning*, *2*(2–3), 141–155. https://doi.org/10.1007/s11409-007-9012-y

Mayer, R. E. (2003). The promise of multimedia learning: Using the same instructional design methods across different media. *Learning and Instruction*, *13*(2), 125–139. https://doi.org/10.1016/S0959-4752(02)00016-6

McCrudden, M. T., Marchand, G., & Schutz, P. (2019). Mixed methods in educational psychology inquiry. *Contemporary Educational Psychology*, *57*, 1–8. https://doi.org/10.1016/j.cedpsych.2019.01.008

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. Sage Publications.

Mora, T., Escardíbul, J.-O., & Di Pietro, G. (2018). Computers and students' achievement: An analysis of the One Laptop per Child program in Catalonia. *International Journal of Educational Research*, *92*, 145–157. https://doi.org/10.1016/j.ijer.2018.09.013

Morrow, S. L. (2005). Quality and trustworthiness in qualitative research in counseling psychology. *Journal of Counseling Psychology*, *52*(2), 250–260. https://doi.org/10.1037/0022-0167.52.2.250

Muis, K. R., Psaradellis, C., Chevrier, M., Di Leo, I., & Lajoie, S. P. (2016). Learning by preparing to teach: Fostering self-regulatory processes and achievement during complex mathematics problem solving. *Journal of Educational Psychology*, *108*(4), 474–492. https://doi.org/10.1037/edu0000071

Muis, K. R., Ranellucci, J., Trevors, G., & Duffy, M. C. (2015). The effects of technology-mediated immediate feedback on kindergarten students' attitudes, emotions, engagement and learning outcomes during literacy skills development. *Learning & Instruction*, *38*, 1–13. a9h. https://doi.org/10.1016/j.learninstruc.2015.02.001

Panadero, E. (2017). A review of self-regulated learning: Six models and four directions for research. *Frontiers in Psychology*, *8*(422), 28. https://doi.org/10.3389/fpsyg.2017.00422

Paris, S. G., & Flukes, J. (2005). Assessing children's metacognition about strategic reading. In S. E. Israel, C. C. Block, K. L. Bauserman, & K. Kinnucan-Welsch (Eds.), *Metacognition in literacy learning: Theory, assessment, instruction, and professional development.* (2005-07525-007; pp. 121–139). Lawrence Erlbaum Associates Publishers.

Pintrich, P. R. (1999). The role of motivation in promoting and sustaining self-regulated learning. *International Journal of Educational Research*, *31*(6), 459–470. https://doi.org/10.1016/S0883-0355(99)00015-4

Pintrich, P. R., & de Groot, E. V. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology*, *82*(1), 33–40. https://doi.org/10.1037/0022-0663.82.1.33

Ponce, H. R., Mayer, R. E., & Lopez, M. J. (2013). A computer-based spatial learning strategy approach that improves reading comprehension and writing. *Educational Technology Research and Development*, *61*(5), 819–840. https://doi.org/10.1007/s11423-013-9310-9

Postholm, M. B. (2011). Self-regulated learning in teaching: Students' experiences. *Teachers and Teaching: Theory and Practice*, *17*(3), 365–382.

Pratt, S. M., & Martin, A. M. (2017). The differential impact of video-stimulated recall and concurrent questioning methods on beginning readers' verbalization about self-monitoring during oral reading. *Reading Psychology*, *38*(5), 439–485. https://doi.org/10.1080/02702711.2017.1290726

Pressley, M., & Afflerbach, P. (1995). *Verbal protocols of reading: The nature of constructively responsive reading*. Lawrence Erlbaum Associates.

Price, S., & Oliver, M. (2007). A framework for conceptualising the impact of technology on teaching and learning. *Journal of Educational Technology & Society*, *10*(1), 16–27.

Qi, X. (2021). Effects of self-regulated learning on student's reading literacy: Evidence from Shanghai. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.555849

Robinson, K. (2016). The effect of technology integration on high school student's literacy achievement. *Teaching English with Technology*, *16*(3), 3–16.

Robson, S. (2016). Are there differences between children's display of self-regulation and metacognition when engaged in an activity and when later reflecting on it? The complementary roles of observation and reflective dialogue. *Early Years: An International Journal of Research and Development*, *36*(2), 179–194. https://doi.org/10.1080/09575146.2015.1129315

Roussel, S. (2011). A computer assisted method to track listening strategies in second language learning. *ReCALL*, *23*(2), 98–116. http://dx.doi.org/10.1017/S0958344011000036

Salmerón, L., Delgado, P., Vargas, C., & Gil, L. (2021). Tablets for all? Testing the screen inferiority effect with upper primary school students. *Learning and Individual Differences*, *86*, 8. https://doi.org/10.1016/j.lindif.2021.101975

Saunders, B., Sim, J., Kingstone, T., Baker, S., Waterfield, J., Bartlam, B., Burroughs, H., & Jinks, C. (2018). Saturation in qualitative research: Exploring its conceptualization and operationalization. *Quality & Quantity*, *52*(4), 1893–1907. https://doi.org/10.1007/s11135-017-0574-8

Schacter, D. L., & Szpunar, K. K. (2015). Enhancing attention and memory during video-recorded lectures. *Scholarship of Teaching and Learning in Psychology*, *1*(1), 60–71. https://doi.org/10.1037/stl0000011

Schiavo, G., Mana, N., Mich, O., Zancanaro, M., & Job, R. (2021). Attention-driven read-aloud technology increases reading comprehension in children with reading disabilities. *Journal of Computer Assisted Learning*, *37*(3), 875-886. https://doi.org/10.1111/jcal.12530

Schraw, G., & Dennison, R. S. (1994). Assessing metacognitive awareness. *Contemporary Educational Psychology*, *19*(4), 460–475. https://doi.org/10.1006/ceps.1994.1033

Schunk, D. (2008). Metacognition, self-regulation, and self-regulated learning: Research recommendations. *Educational Psychology Review*, *20*(4), 463–467. https://doi.org/10.1007/s10648-008-9086-3

Schwartz, N. H., Ellsworth, L. S., Graham, L., & Knight, B. (1998). Accessing prior knowledge to remember text: A comparison of advance organizers and maps. *Contemporary Educational Psychology*, *23*(1), 65–89. https://doi.org/10.1006/ceps.1997.0958

Serrano, M.-Á., Vidal-Abarca, E., & Ferrer, A. (2018). Teaching self-regulation strategies via an intelligent tutoring system (TuinLECweb): Effects for low-skilled comprehenders. *Journal of Computer Assisted Learning*, *34*(5), 515–525. https://doi.org/10.1111/jcal.12256

Sha, L., Looi, C.-K., Chen, W., Seow, P., & Wong, L.-H. (2012). Recognizing and measuring self-regulated learning in a mobile learning environment. *Computers in Human Behavior*, *28*(2), 718–728. https://doi.org/10.1016/j.chb.2011.11.019

Smith, M. (2016). Computer science for all. *Whitehouse.Gov*. https://obamawhitehouse.archives.gov/blog/2016/01/30/computer-science-all

Sperling, R. A., Howard, B. C., Miller, L. A., & Murphy, C. (2002). Measures of children's knowledge and regulation of cognition. *Contemporary Educational Psychology*, *27*(1), 51–79. https://doi.org/10.1006/ceps.2001.1091

Squire, L. R. (2009). Memory and brain systems: 1969-2009. *Journal of Neuroscience, 29*(41), 12711-12716. https://doi.org/10.1523/JNEUROSCI.3575-09.2009

Stoop, J., Kreutzer, P., & Kircz, J. (2013). Reading and learning from screens versus print: A study in changing habits: Part 1 – reading long information rich texts. *New Library World*, *114*(7/8), 284–300. https://doi.org/10.1108/NLW-01-2013-0012

Storz, M. G., & Hoffman, A. R. (2013). Examining response to a one-to-one computer initiative: Student and teacher voices. *RMLE Online: Research in Middle Level Education*, *36*(6), 1–18. https://doi.org/10.1080/19404476.2013.11462099

Tashakkori, A., & Teddlie, C. (1998). *Mixed methodology: Combining qualitative and quantitative approaches* (Vol. 46). SAGE Publications.

The White House. (2021). *Executive order on supporting the reopening and continuing operation of schools and early childhood education providers* [Governmental]. The White House Briefing Room. https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/21/executive-order-supporting-the-reopening-and-continuing-operation-of-schools-and-early-childhood-education-providers/

U.S. Department of Education. (2016). *Future ready learning: Reimagining the role of technology in education*. Office of Educational Technology. https://tech.ed.gov/netp/learning/

Vidal-Abarca, E., Mañá, A., & Gil, L. (2010). Individual differences for self-regulating task-oriented reading activities. *Journal of Educational Psychology*, *102*(4), 817–826. https://doi.org/10.1037/a0020062

Wilson, V. A. (1998). *Qualitative research: An introduction. Purposes, methodology, criteria for judgment, and a rationale for mixed methodology.* (Mixed Method Evaluation ED 423 285; p. 18). https://files.eric.ed.gov/fulltext/ED423285.pdf

Xu, Y., Wang, D., Collins, P., Lee, H., & Warschauer, M. (2021). Same benefits, different communication patterns: Comparing children's reading with a conversational agent vs. a human partner. *Computers & Education*, *161*, 104059. https://doi.org/10.1016/j.compedu.2020.104059

Yin, R. K. (2011). Ch. 5 Doing Fieldwork. In *Qualitative research from start to finish* (pp. 109–128). Guilford Press.

Zheng, B., Warschauer, M., Lin, C.-H., & Chang, C. (2016). Learning in one-to-one laptop environments: A meta-analysis and research synthesis. *Review of Educational Research*, *86*(4), 1052–1084. https://doi.org/10.3102/0034654316628645

Zimmerman, B. J. (1989). A social cognitive view of self-regulated academic learning. *Journal of Educational Psychology*, *81*(3), 329–339. https://doi.org/10.1037/0022-0663.81.3.329

Zimmerman, B. J., & Martinez Pons, M. (1986). Development of a structured interview for assessing student use of self-regulated learning strategies. *American Educational Research Journal*, *23*(4), 614–628.