Optional ERIC Coversheet — Only for Use with U.S. Department of Education Grantee Submissions

This coversheet should be completed by grantees and added to the PDF of your submission if the information required in this form **is not included on the PDF to be submitted**.

INSTRUCTIONS

- Before beginning submission process, download this PDF coversheet if you will need to provide information not on the PDF.
- Fill in all fields—information in this form **must match** the information on the submitted PDF and add missing information.
- Attach completed coversheet to the PDF you will upload to ERIC [use Adobe Acrobat or other program to combine PDF files]—do not upload the coversheet as a separate document.
- Begin completing submission form at https://eric.ed.gov/submit/ and upload the full-text PDF with attached coversheet when indicated. Your full-text PDF will display in ERIC after the 12-month embargo period.

GRANTEE SUBMISSION REQUIRED FIELDS

Title of article, paper, or other content

iSTART-Early and Now I Can Read: Effective Reading Strategies for Young Readers

All author name(s) and affiliations on PDF. If more than 6 names, ERIC will complete the list from the submitted PDF.

Last Name, First Name	Academic/Organizational Affiliation	ORCID ID
Watanabe, Micah	Arizona State University	
Arner, Tracy	Arizona State University	
McNamara, Danielle	Arizona State University	

Publication/Completion Date—(if *In Press,* enter year accepted or completed) 2023

Check type of content being submitted and complete one of the following in the box below:

- ☑ If article: Name of journal, volume, and issue number if available
- ☐ If paper: Name of conference, date of conference, and place of conference
- ☐ If book chapter: Title of book, page range, publisher name and location
- ☐ If book: Publisher name and location
- ☐ If dissertation: Name of institution, type of degree, and department granting degree

The Reading Teacher, Advance Online Publication

DOI or URL to published work (if available) https://doi.org/10.1002/trtr.2270

Acknowledgement of Funding— Grantees should check with their grant officer for the preferred wording to acknowledge funding. If the grant officer does not have a preference, grantees can use this suggested wording (adjust wording if multiple grants are to be acknowledged). Fill in Department of Education funding office, grant number, and name of grant recipient institution or organization.

"This work was supported by U.S. Department of Education **[Office name]** National Center for Educat through **[Grant number]** R305A1900 to **Institution]** Arizona State U. The opinions expressed are those of the authors and do not represent views of the **[Office name]** National Center for Educa or the U.S. Department of Education.

VIEWPOINT

INTERNATIONAL LITERACY ASSOCIATION

iSTART-Early and Now I Can Read: Effective Reading Strategies for Young Readers

Micah Watanabe, Tracy Arner, Danielle McNamara

This article introduces teachers to iSTART-Early, a game-based reading tutor that provides for developing readers to build knowledge and practice comprehension strategies.

Introduction

David Stephens, a 4th grade teacher in Washington State, was preparing a lesson plan about desert wildlife (all names are pseudonyms). He was planning on assigning his students the chapter book, "Desert Giant: The World of the Saguaro Cactus." The students had divergent knowledge about the topic. For example, Maryam had grown up in Arizona, and had a lot of personal knowledge and experience with the topics in the book. Theo had gone on vacation to the Grand Canyon and his parents made sure he read all the informational signs. Julie had little knowledge about the desert, all her family vacations were to Canada.

Mr. Stephens was concerned that not all his students would be able to understand the words or ideas in the book, and searched for instructional strategies that he could teach his students that would help all of them better understand what they read. At an education conference, he had seen a demonstration of a reading comprehension tutoring system, iSTART-Early (Kendeou et al., 2022). He decided to research both the system and the evidence behind it to see if it was right for his students.

Mr. Stephens recognizes that his students are at a critical point in their reading development. The most recent National Assessment of Educational Progress (NAEP, 2022) found that only 32% of 4th graders score as proficient or advanced in reading comprehension. Those who may have been at or above grade level in reading *decoding* assessments may not have mastered the skills necessary to comprehend the full text (Best et al., 2004; Stockard, 2010). For example, students like Julie who lack topic-specific knowledge, a key contributor to reading comprehension, may fall behind their peers on reading *comprehension* assessments as they enter 4th grade. What Julie and others experience is frequently referred to as the "fourth grade slump."

The focus of Mr. Stephens' *instructional* materials is shifting from teaching students the skills needed to decode and read texts (e.g., alphabetic principle, phonemic awareness, word decoding) to students reading texts to acquire knowledge. That is, the curriculum is switching focus from "learning to read" to "reading to learn." Unfortunately, the "learning to read," "reading to learn" distinction is based on a misconception. The misconception is that children must learn to read before they can learn how to use comprehension strategies that enable reading to learn. This misconception has been reinforced by theories of working memory resources that assume that early readers must have mastered decoding skills to free up the resources needed to devote to comprehension. Additionally, materials used to teach reading further reinforce the emphasis on decoding skills as the linchpin for comprehension while relegating domain knowledge and reading strategies to a secondary or non-existent role (Wexler, 2020).

In fact, research has demonstrated that young students are able to use their knowledge and comprehension strategies to generate inferences and comprehend texts (Cain & Oakhill, 1999, 2009) and in some cases, use their knowledge and comprehension to improve their decoding skills (Cain et al., 2003). Unfortunately, in many cases, the students who struggle to master decoding skills are not provided

Micah Watanabe is a Research Scientist at the Learning Engineering Institute at Arizona State University, Tempe, Arizona, USA; email mwatana5@asu.edu.

Tracy Arner is the Assistant Director of the Learning Engineering Institute at Arizona State University, Tempe, Arizona, USA; email tarner@asu.edu.

Danielle McNamara is the Executive Director of the Learning Engineering Institute at Arizona State University, Tempe, Arizona, USA; email danielle.mcnamara@asu.edu.

 doi:10.1002/trtr.2270

with content that builds their knowledge and are not given instruction on how to comprehend challenging material (i.e., strategies). Thus, the misconception that students must achieve perfect decoding *before* reading to learn has contributed to a large number of students being left behind.

The solution to the false dichotomy created by "learning to read"—"reading to learn" is twofold. First, young children, from the time they are born, must be exposed to content that builds their knowledge of the world and, particularly for school, their knowledge of history and science. Research on comprehension has demonstrated that knowledge is foundational to generating the inferences required to understand a text (Kintsch, 1998). Furthermore, children do not need *reading* skills to build knowledge and learn how to comprehend challenging content. For example, lived experiences such as growing up in the desert like Maryam or visiting the Grand Canyon like Theo can increase their knowledge. Students who struggle to learn to read (i.e., learn to decode) must first be building their knowledge base.

PAUSE AND PONDER

- Why is knowledge important for my students to understand and learn new content?
- How can I bring knowledge building into my classroom?
- How can I create a community of knowledge builders in my classroom?
- When should I begin to teach comprehension strategies?
- What comprehension strategies will help my students tackle challenging texts?

Second, students must have practice in engaging in reading comprehension strategies. Students who are highly skilled readers may spontaneously use a variety of strategies to support comprehension of the variety of fiction and non-fiction texts they engage with in the pursuit of knowledge (McNamara, 2004; Zwaan et al., 1995). Students who use comprehension strategies can also build their knowledge base, as the more content students are able to comprehend, the easier it is for them to acquire new knowledge. Conversely, students who are less skilled struggle with implementing strategies that will help them comprehend texts, particularly those that are complex informational texts such as science texts. Yet, these are the texts that students need most to acquire new knowledge. Consequently, when they are faced with the task of reading to learn (often in the 3rd and 4th grades in the US), they struggle to do so because they lack both domain knowledge and comprehension skills. Indeed, these students struggle with acquiring the knowledge that will, in turn, support future knowledge acquisition. In sum, students who have adequate reading skills acquire knowledge easier and faster than those who do not. This is known as the Matthew effect (Hirsch, 2003). Fortunately for educators and students like Julie who do not have sufficient knowledge bases, research has demonstrated that students *can* overcome knowledge gaps by using reading comprehension strategies. When these students do catch up to their peers in decoding, they will be ready to read to learn.

Considerable research has suggested the importance of students building knowledge beginning at birth and continuing in conjunction with instruction on foundational reading skills. Yet, recent reporting by Emily Hanford (Hanford, 2018, 2019) reveals that findings from the science of reading have not yet penetrated curricula or teacher education programs. Therefore, teachers are ill-equipped to implement evidence-based practice when teaching students to read and lack the resources necessary to bridge the gap in their preparation (Hindman et al., 2020). A viable approach is needed to help students succeed in developing the individual reading skills necessary to read texts, and reading comprehension strategies that are essential for acquiring knowledge. As Mr. Stephens and teachers like him discovered, there are evidence-based tools that provide both instruction and practice opportunities for young readers to develop their reading comprehension skills and build their knowledge base.

What Is Comprehension?

As Mr. Stephens began reading about iSTART-Early, he was pleased to find out that iSTART-Early is backed by more than 40 years of research on reading comprehension. Comprehension is the process of integrating the ideas and constructs that emerge in the mind of the reader. iSTART-Early is built on theories of text comprehension describing the reading comprehension process in terms of three key levels: the surface model, textbase, and situation model (Kintsch & van Dijk, 1978). These three levels are a part of the reader's *mental representation* of the text. The surface model consists of the *explicit* words and sentences in the text. The textbase consists of the readers' understanding of the *meaning* of the words and sentences in the text, as well as their relations within the text. The situation model consists of the understanding of the text that emerges as the reader connects the ideas in the text to each other and to their own prior knowledge. The reader's situation model is also known as their *deep comprehension* of the text because they are using what they already know about the topic, domain, and world to make sense of the text. When the textbase and situation model are well integrated with prior knowledge, the emergent mental representation is *coherent* because there are more connections that bind new and old information. A coherent mental representation results in better knowledge building, which can in turn support future learning.

Crucially, in the process of comprehension, *understanding the words and sentences is necessary, but not sufficient, for comprehension* (Moravcsik & Kintsch, 1993). A strong surface model of the text does not result in deep comprehension because the readers must generate *inferences* to achieve deep comprehension of the text. Inference generation is the process of making connections between ideas in a text that are not explicit and connecting ideas in the text (both explicit and inferred) to prior knowledge. For example, consider the following two sentences:

Thomas walked over the bridge.
Janice kayaked under the bridge.

While not explicit, these two sentences can be connected by the inference: *Janice is below Thomas*. Inferencing is the keystone of comprehension because it binds the ideas together (McNamara, 2021). Knowledge is an essential piece of comprehension because knowledge affords readers the ability to generate inferences. In the example above, world knowledge of bridges and kayaks is required to generate the inference. As such, knowledge building is key to comprehension and learning (Bereiter & Scardamalia, 1996).

Fortunately for teachers like Mr. Stephens, there are interactive effects of students' comprehension skills and the texts that they read (McNamara & Kintsch, 1996). Less skilled and knowledgeable students can better comprehend texts that are *cohesive*. Cohesive texts use repeated words and phrases across sentences and paragraphs to make the connections between ideas more explicit (Ozuru et al., 2009). In contrast, more skilled and knowledgeable students can benefit from less cohesive texts because they are challenged to generate these connections by themselves. Teachers can assign texts within students' Zone of Proximal Development (Vygotsky, 2012) by assigning more cohesive texts to less skilled students, and more challenging texts to skilled students. However, for teachers like Mr. Stephens, there are time constraints on their ability to teach comprehension strategies and assign personalized texts for students to practice on. Thus, there is a need for *intelligent tutoring systems* (ITS) that are able to support teachers' instructional goals. As we will explore in the following sections, iSTART-Early is specifically designed to support teachers and students by teaching effective comprehension strategies and providing opportunities for students to practice.

Comprehension Strategy Instruction in iSTART-Early

After reading about the nature of comprehension, Mr. Stephens realized he needed to teach his students simple, effective reading comprehension strategies, and have them practice the strategies on texts that span a range of domains and topics. This approach is backed by the science of reading evidence which demonstrates that teaching 2nd–4th grade students' reading comprehension strategies can enhance their knowledge acquisition and retention (Cain & Oakhill, 2009; Reutzel et al., 2005; van den Broek et al., 2015). In particular, teaching students a set or family of related strategies is recommended as students can be taught to coordinate the different strategies (Reutzel et al., 2005). This approach helps the students build their knowledge and practice transferring comprehension strategies to new topics. Mr. Stephens was excited to test iSTART-Early (Kendeou et al., 2022) in his classroom, as it was able to provide reading comprehension instruction at different levels based on his students' different levels of skill and knowledge.

iSTART-Early provides instruction on a family of related comprehension strategies: question asking, paraphrasing, finding information and answers in the text, bridging and elaborating, and summarizing. The selection of these strategies was informed by research on the effectiveness of explanation as a reading comprehension strategy (McNamara, 2004). These strategies have also been included in past versions of iSTART (McNamara et al., 2004; Snow et al., 2016) and have been demonstrated to improve reading comprehension for students at different grade and skill levels (Johnson et al., 2017; McCarthy et al., 2020; McNamara et al., 2004; Snow et al., 2016).

The unifying idea behind these reading strategies is to enhance students' activation of knowledge and inference generation while reading, resulting in longer lasting mental representations and greater knowledge building. The strategies are taught via interactive lessons (see Figure 1) that include multiple opportunities for students to check their understanding of the strategy and receive feedback by responding to selected response questions. These questions serve to check students' understanding of the strategy and ensure students are practicing the strategies immediately after they are learned.

Question Asking

Question asking is a starting point for students to generate inferences (McCrudden & McNamara, 2017). Research demonstrates that teaching students the importance of asking questions, how to ask questions, to answer their questions, and to evaluate the quality of their questions leads to improved comprehension (Cohen, 1983; Davey & McBride, 1986). For example, Davey and McBride (1986) found that students who were given question asking training wrote higher quality questions, scored higher on both literal and inference comprehension questions, and had

Figure 1
An Example of an Interactive Lesson from iSTART-Early

better metacomprehension accuracy compared to students in comparison conditions. Additionally, having readers generate questions about the text encourages comprehension and movement toward making links between ideas across sentences (King, 1994; Rosenshine et al., 1996). Students who ask higher quality questions also recall more information from the text and answer more questions correctly about the text (Rosenshine et al., 1996).

Questions vary in type (e.g., verification, definition, interpretational) and in depth of reasoning (shallow or deep reasoning; Graesser & Person, 1994). It is important for readers to generate a variety of questions. For example, consider the sentence, "The dog was lackadaisical." A shallow question about the meaning of a word (e.g., what does "lackadaisical" mean?) can afford the reader an opportunity to generate a more accurate paraphrase ("the dog was lacking something?" vs. "the dog was lazy"). A more accurate mental representation of the text allows the reader to create a stronger connection between the textual information and their prior knowledge which is necessary for deeper comprehension.

In comparison to shallow questions, deep-reasoning questions go beyond ideas that are explicit in the text. For example, deep-reasoning questions ask for explanations about relations, events, and processes to further understanding of how or why something occurred (e.g., "What made the dog lackadaisical?"). Searching for answers to deep-reasoning questions encourages readers to connect between the ideas (and sentences) in a text or use prior knowledge to generate inferences and elaborations. Paraphrasing, bridging ideas, and generating inferences are key comprehension strategies (see below) and question asking can increase students' propensity to engage in further reading strategies.

Paraphrasing

Paraphrasing is restating the text in different words, and preferably, in a reader's own words. It is an important part of the comprehension process because readers often paraphrase the sentence in order to begin an explanation (McNamara, 2004; McNamara et al., 2023). Paraphrases are important because they help the reader to better understand the information in the sentences, and thus help the reader, particularly less skilled readers, to develop a better textbase level understanding of the text (McNamara et al., 2006). Essentially, the act of paraphrasing externalizes the reader's understanding. This process can force the reader to fill in conceptual gaps and facilitates the activation of relevant concepts that are necessary to generate inferences (Best et al., 2005).

Finding Information in Text

When reading a text, students must find key information. For instance, it is important for students to identify what the author is saying (e.g., key ideas), how they are saying it (e.g., word choice, details), and why they are saying it (e.g., authorial intent or goal). When students successfully find this information, they are better able to complete more complex comprehension strategies (see below). For example, a reader's summary of a text will be significantly improved if they find the key ideas and supporting details in the text.

Explaining—Bridging & Elaboration

Explaining the meaning of the text to oneself while reading can improve the generation of inferences and enhance comprehension (McNamara, 2004). Past research has found that the use of two strategies, bridging and elaboration, can increase the readers' propensity to generate connections between the text and knowledge. Bridging and elaboration have been found to improve performance in a number of comprehension tasks (Feller et al., 2020; McCrudden et al., 2021; McNamara, 2004; van den Broek et al., 2015).

Bridging inferences link ideas and the relations between separate sentences in the text. Making bridging inferences is critical to text comprehension because texts normally do not (or cannot) state all of the relevant information (e.g., McNamara & Kintsch, 1996). Deep comprehension requires more than merely interpreting individual sentences; the reader must also be able to integrate individual sentence meanings into a coherent text level representation (Gernsbacher, 1997; Kintsch, 1988, 1998). Therefore, to successfully comprehend a text, the reader must generate

bridging inferences to build a coherent mental model that connects the separate ideas across the text.

Elaboration is the process of making inferences that link what is in the text or sentence to related knowledge. For example, when reading this sentence about heart disease, "Coronary artery disease occurs when the arteries become hardened and narrowed," the reader might make a connection to prior knowledge that arteries supply blood to the heart muscle. The reader might also use general knowledge or logic to infer that narrowed arteries would reduce blood flow to the heart muscle and result in a lack of oxygen supply and potentially lead to a heart attack. Encouraging readers to use logic and common sense helps them to understand that it is possible to make sense of the text, and go beyond the text, without knowing a lot about the topic (McNamara, 2004).

Summarizing

While question asking and explaining encourage elaborating the text with more information to generate inferences, the goal of summarization is to reduce the text to its core ideas. The summarization process helps readers integrate content with pre-existing knowledge (Wade-Stein & Kintsch, 2004), and better retain text material (Rinehart et al., 1986). Summarizing reinforces readers' mental representations of the content, enhancing not only retention of text material (Rinehart et al., 1986), but also conceptual understanding (Wade-Stein & Kintsch, 2004), particularly for lower achieving students and those with learning disabilities (Gil et al., 2010). In a recent meta-analysis, Graham and Hebert (2011) reported that summarization enhanced comprehension in 18 out of 19 studies.

Comprehension Strategy Practice in iSTART-Early

Mr. Stephens realized that once his students had been taught strategies, they needed to *deliberately practice* those strategies in order to improve their ability to execute reading strategies across different texts. Students who practice without goals or feedback are less likely to master new skills. For instance, a study by Plant et al. (2005) found that the amount of time spent studying was not predictive of college students' grade point average (GPA), rather, the *quality* of the time spent studying predicted GPA.

Thus, in iSTART-Early students are provided with two types of deliberate practice modules: coached practice, and generative games. Coached practice is the most basic form of practice, where students generate think-alouds while reading, and are given feedback on the quality of their responses. The responses are scored using natural language processing (NLP) algorithms that have been shown to correlate with teachers scores of writing quality, such as their responses to reading or summaries (Allen et al., 2015; Crossley et al., 2019), and demonstrated to be predictive of students' reading comprehension (McNamara et al., 2007).

Generative games (see Figure 2) use the same structure as coached practice (students write or speak think-alouds while reading) however, they include a gamified aspect to improve their motivation and engagement. A considerable amount of evidence suggests that educational technology (e.g., games, interactive applications, intelligent tutoring systems) improves a variety of student level-outcomes, such as motivation, engagement, and learning (e.g., D'Mello, 2013; Jackson & McNamara, 2013). Both types of practice include automated formative and summative feedback designed to address students'

Figure 2
An Example of a Game in iSTART-Early

individual practice needs. Furthermore, practice opportunities within iSTART-Early are *adaptive*, as students read more texts, their think-aloud scores are used to select new texts for them. For instance, if a reader receives low scores across a text, the system will select a new text that is one level lower.

Teacher Tools in iSTART-Early

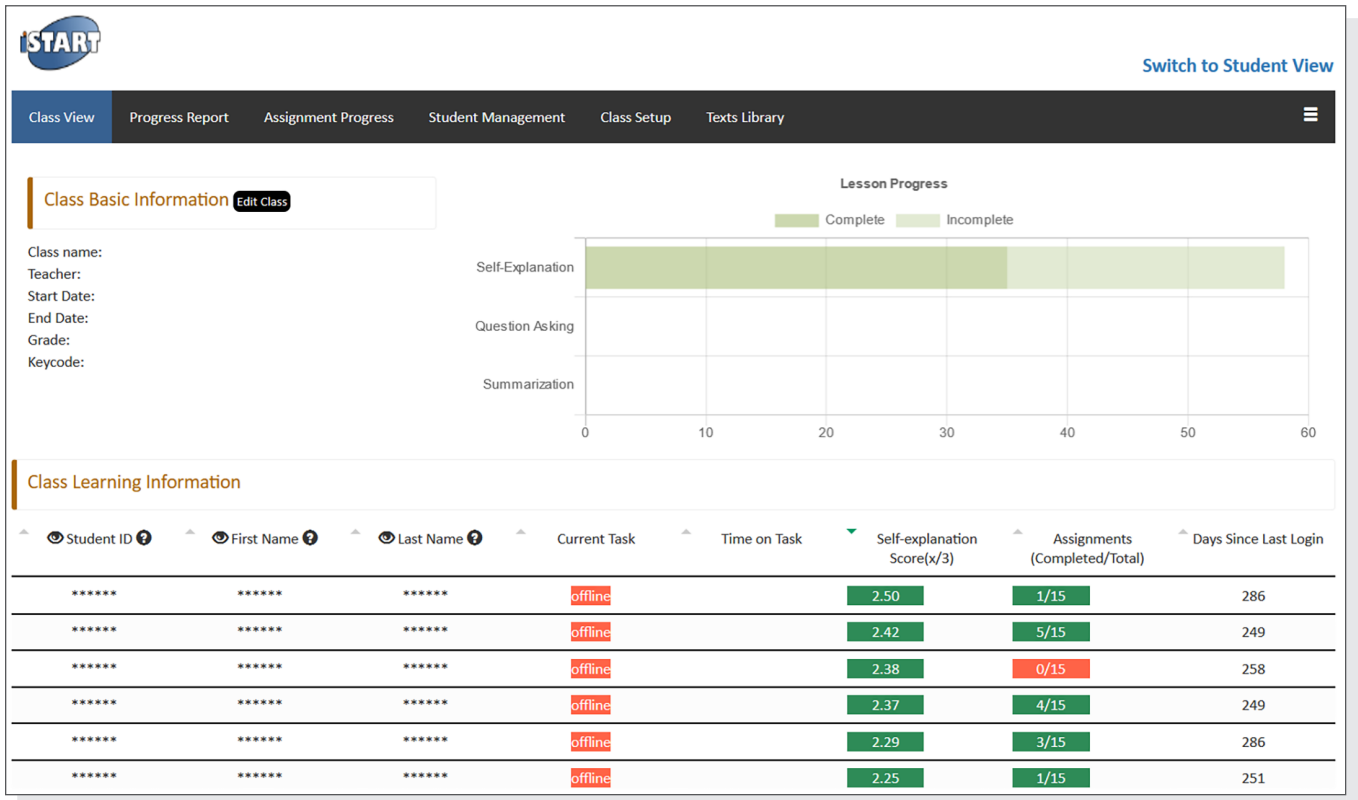
Mr. Stephens was impressed by the teacher tools available in iSTART-Early. iSTART-early includes tutorial videos and teacher professional development resources to help teachers integrate iSTART-Early into their classrooms. For example, teachers have the ability to integrate their course materials into the students' experience on iSTART-Early. Instructors can access a teacher interface (see Figure 3) that allows them to upload their own texts and select target or key sentences for students to practice their strategies on. In addition, teachers can create both group or custom text assignments for their students, which allows teachers to cover key materials as well as target texts to students who need more support or challenges. In addition, teachers can monitor students' performance across different strategies by viewing their performance in lessons and games.

Conclusion

Mr. Stephens was thrilled with his class's progress after he implemented iSTART-Early. Students across the knowledge and skill spectrum were getting the instruction they needed in order to improve their reading skill. Students like Julie were learning reading comprehension skills that allowed them to overcome knowledge gaps and learn from texts. Students like Maryam and Theo were being challenged with harder texts and practicing their reading comprehension strategies on texts on different topics in history and science.

iSTART-Early is targeted specifically at students in the 3rd and 4th grade who are struggling to navigate the "learning to read"—"reading to learn" transition. iSTART-Early is built on decades of research in reading, modern theories of motivating students with game-based learning and enhancing their skills with deliberate practice. iSTART-Early is currently in the final stages of development, and teachers and schools can sign up to be notified of opportunities to participate in testing of iSTART-Early at www.adaptiveliteracy.com. iSTART, the precursor to iSTART-Early has been proven effective for a range of readers at different skill and grade levels (McNamara et al., 2004; Snow et al., 2016). iSTART includes instruction videos and games for question asking, paraphrasing, explaining

Figure 3
iSTART-Early Teacher Interface



TAKE ACTION!

1. Engage in knowledge-building activities with developing readers so that they can use their knowledge base to understand texts when they must read to learn.
2. Build students' vocabulary through lessons—both explicit instruction (flashcards, definitions) and implicit so that they can use their vocabulary to understand texts.
3. Introduce simple comprehension strategies (i.e., question asking, paraphrasing) early so that students can practice using them on a variety of texts.
4. Provide opportunities for students to deliberately practice comprehension strategies (i.e., reading aloud) with feedback on their performance.
5. Lead discussions with students to facilitate knowledge growth and reading comprehension.
6. Structure curriculum and lesson plans to meet students' interests and skills. This can motivate students to practice reading and build knowledge.
7. Use texts as tools for developing students' learning and communication skills. Scaffolding texts to students' reading abilities can promote knowledge growth as they move from easier to more difficult texts.

(bridging and elaboration), and summarization. iSTART is freely available to students, parents, teachers, and schools through www.adaptiveliteracy.com.

Disclaimer

Viewpoint articles are commentaries that do not undergo peer review and may not reflect the opinions and beliefs of ILA and the journal editors.

Funding Information

Institute of Education Sciences, R305A190050.

REFERENCES

Allen, L. K., Snow, E. L., & McNamara, D. S. (2015). Are you reading my mind? Modeling students' reading comprehension skills with natural language processing techniques. In J. Baron, G. Lynch, N. Maziarz, P. Bilkstein, A. Merceron, & G. Siemens (Eds.), *Proceedings of the fifth international conference on learning analytics and knowledge (LAK '15)* (pp. 246–254). Association for Computing Machinery. https://doi.org/10.1145/2723576.2723617

Bereiter, C., & Scardamalia, M. (1996). Rethinking learning. In D. R. Olson & N. Torrance (Eds.), *The handbook of education and human development: new models of learning, teaching and schooling* (Vol. 1, pp. 485–513). Blackwell Publishers Ltd. https://doi.org/10.1111/b.9780631211860.1998.00023.x

Best, R., Floyd, R. G., & McNamara, D. S. (2004). Understanding the fourth-grade slump: Comprehension difficulties as a function of reader aptitudes and text genre. In *85th Annual Meeting of the American Educational Research Association*.

Best, R. M., Rowe, M., Ozuru, Y., & McNamara, D. S. (2005). Deep-level comprehension of science texts: The role of the reader and the text. *Topics in Language Disorders*, *25*(1), 65–83. https://doi.org/10.1097/00011363-200501000-00007

Cain, K., & Oakhill, J. V. (1999). Inference making ability and its relation to comprehension failure in young children. *Reading and Writing*, *11*, 489–503. https://doi.org/10.1023/A:1008084120205

Cain, K., & Oakhill, J. V. (2009). Reading comprehension development from 8 to 14 years. In R. K. Wagner, C. Schatschneider, & C. Phythian-Sence (Eds.), *Beyond decoding: The behavioral and biological foundations of reading comprehension* (pp. 143–175). The Guilford Press.

Cain, K., Oakhill, J. V., & Elbro, C. (2003). The ability to learn new word meanings from context by school-age children with and without language comprehension difficulties. *Journal of Child Language*, *30*(3), 681–694. https://doi.org/10.1017/S0305000903005713

Cohen, R. (1983). Self-generated questions as an aid to reading comprehension. *The Reading Teacher*, *36*(8), 770–775. https://www.jstor.org/stable/20198324

Crossley, S. A., Kim, M., Allen, L., & McNamara, D. (2019). Automated summarization evaluation (ASE) using natural language processing tools. In S. Isotani, E. Millán, A. Ogan, P. Hastings, B. McLaren, & R. Luckin (Eds.), *Artificial Intelligence in Education: 20th International Conference, AIED 2019, Chicago, IL, USA, June 25-29, 2019, Proceedings, Part I* (pp. 84–95). Springer International Publishing. https://doi.org/10.1007/978-3-030-23204-7_8

Davey, B., & McBride, S. (1986). Generating self-questions after reading: A comprehension assist for elementary students. *The Journal of Educational Research*, *80*(1), 43–46. https://doi.org/10.1080/00220671.1986.10885720

D'Mello, S. (2013). A selective meta-analysis on the relative incidence of discrete affective states during learning with technology. *Journal of Educational Psychology*, *105*(4), 1082–1099. https://doi.org/10.1037/a0032674

Feller, D. P., Magliano, J., Sabatini, J., O'Reilly, T., & Kopatich, R. D. (2020). Relations between component reading skills, inferences, and comprehension performance in community college readers. *Discourse Processes*, *57*(5–6), 473–490. https://doi.org/10.1080/0163853X.2020.1759175

Gernsbacher, M. A. (1997). Two decades of structure building. *Discourse Processes*, *23*(3), 265–304. https://doi.org/10.1080/01638539709544994

Gil, L., Bråten, I., Vidal-Abarca, E., & Stromso, H. I. (2010). Understanding and integrating multiple science texts: Summary tasks are sometimes better than argument tasks. *Reading Psychology*, *31*(1), 30–68. https://doi.org/10.1080/02702710902733600

Graesser, A. C., & Person, N. K. (1994). Question asking during tutoring. *American Educational Research Journal*, *31*(1), 104–137. https://doi.org/10.3102/00028312031001104

Graham, S., & Hebert, M. (2011). Writing to read: A meta-analysis of the impact of writing and writing instruction on reading. *Harvard Educational Review*, *81*(4), 710–744. https://doi.org/10.17763/haer.81.4.t2k0m13756113566

Hanford, E. (2018, October 26). Why are we still teaching reading the wrong way. *The New York Times*. https://www.nytimes.com/2018/10/26/opinion/sunday/phonics-teaching-reading-wrong-way.html

Hanford, E. (2019, January 2). *Why millions of kids can't read and what better teaching can do about it*. NPR. https://www.npr.org/2019/01/02/677722959/why-millions-of-kids-cant-read-and-what-better-teaching-can-do-about-it

Hindman, A. H., Morrison, F. J., Connor, C. M., & Connor, J. A. (2020). Bringing the science of reading to preservice elementary teachers: Tools that bridge research and practice. *Reading Research Quarterly*, *55*, S197–S206. https://doi.org/10.1002/rrq.345

Hirsch, E. D. (2003). Reading comprehension requires knowledge of words and the world. *American Educator*, *27*(1), 10–13.

Jackson, G. T., & McNamara, D. S. (2013). Motivation and performance in a game-based intelligent tutoring system. *Journal of Educational Psychology*, *105*(4), 1036–1049. https://doi.org/10.1037/a0032580

Johnson, A. M., Guerrero, T. A., Tighe, E. L., & McNamara, D. S. (2017). iSTART-ALL: Confronting adult low literacy with intelligent tutoring for reading comprehension. In E. André, R. Baker, X. Hu, M. T. Rodrigo, & B. du Boulay (Eds.), *Artificial Intelligence in Education: 18th International Conference, AIED 2017, Wuhan, China, June 28–July 1, 2017, Proceedings 18* (pp. 125–136). Springer International Publishing. https://doi.org/10.1007/978-3-319-61425-0_11

Kendeou, P., Orcutt, E., Arner, T., Li, T., Balyan, R., Butterfuss, R., Watanabe, M., & McNamara, D. (2022). iSTART-early: Interactive strategy training for early readers. In S. Crossley & E. Popescu (Eds.), *International conference on intelligent tutoring systems* (pp. 371–379). Springer International Publishing.

King, A. (1994). Autonomy and question asking: The role of personal control in guided student-generated questioning. *Learning and Individual Differences*, *6*(2), 163–185. https://doi.org/10.1016/1041-6080(94)90008-6

Kintsch, W. (1988). The role of knowledge in discourse comprehension: A construction- integration model. *Psychological Review*, *95*(2), 163–182. https://doi.org/10.1037/0033-295X.95.2.163

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

Kintsch, W., & Van Dijk, T. A. (1978). Toward a model of text comprehension and production. *Psychological Review*, *85*(5), 363–394. https://doi.org/10.1037/0033-295X.85.5.363

McCarthy, K. S., Watanabe, M., Dai, J., & McNamara, D. S. (2020). Personalized learning in iSTART: Past modifications and future design. *Journal of Research on Technology in Education*, *52*(3), 301–321. https://doi.org/10.1080/15391523.2020.1716201

McCrudden, M. T., Huynh, L., Lyu, B., & Kulikowich, J. M. (2021). Bridging inferences and learning from multiple complementary texts. *Discourse Processes*, *58*(5–6), 529–548. https://doi.org/10.1080/0163853X.2021.1924586

McCrudden, M. T., & McNamara, D. S. (2017). *Cognition in education*. Routledge. https://doi.org/10.4324/9781315389080

McNamara, D. S. (2004). SERT: Self-explanation reading training. *Discourse Processes*, *38*(1), 1–30. https://doi.org/10.1207/s15326950dp3801_1

McNamara, D. S. (2021). If integration is the keystone of comprehension: Inferencing is the key. *Discourse Processes*, *58*(1), 86–91. https://doi.org/10.1080/0163853X.2020.1788323

McNamara, D. S., Boonthum, C., Levinstein, I. B., & Millis, K. (2007). Evaluating self-explanations in iSTART: Comparing word-based and LSA algorithms. In T. Landauer, D. S. McNamara, S. Dennis, & W. Kintsch (Eds.), *Handbook of latent semantic analysis* (pp. 227–241). Lawrence Erlbaum Associates.

McNamara, D. S., & Kintsch, W. (1996). Learning from texts: Effects of prior knowledge and text coherence. *Discourse Processes*, *22*(3), 247–288. https://doi.org/10.1080/01638539609544975

McNamara, D. S., Levinstein, I. B., & Boonthum, C. (2004). iSTART: Interactive strategy training for active reading and thinking. *Behavior Research Methods, Instruments, & Computers*, *36*(2), 222–233. https://doi.org/10.3758/BF03195567

McNamara, D. S., Newton, N., Christhilf, K., McCarthy, K. S., Magliano, J. P., & Allen, L. K. (2023). Anchoring your bridge: The importance of paraphrasing to inference making in self-explanations. *Discourse Processes*, *60*(4–5), 337–362. https://doi.org/10.1080/0163853X.2023.2225757

McNamara, D. S., O'Reilly, T. P., Best, R. M., & Ozuru, Y. (2006). Improving adolescent students' reading comprehension with iSTART. *Journal of Educational Computing Research*, *34*(2), 147–171. https://doi.org/10.2190/1RU5-HDTJ-A5C8-JVWE

Moravcsik, J. E., & Kintsch, W. (1993). Writing quality, reading skills, and domain knowledge as factors in text comprehension. *Canadian Journal of Experimental Psychology/Revue Canadienne de Psychologie Expérimentale*, *47*(2), 360–374. https://doi.org/10.1037/h0078823

National Assessment of Educational Progress (NAEP). (2022). The nation's report card. https://nces.ed.gov/nationsreportcard/reading/

Ozuru, Y., Dempsey, K., & McNamara, D. S. (2009). Prior knowledge, reading skill, and text cohesion in the comprehension of science texts. *Learning and Instruction*, *19*(3), 228–242. https://doi.org/10.1016/j.learninstruc.2008.04.003

Plant, E. A., Ericsson, K. A., Hill, L., & Asberg, K. (2005). Why study time does not predict grade point average across college students: Implications of deliberate practice for academic performance. *Contemporary Educational Psychology*, *30*(1), 96–116.

Reutzel, D. R., Smith, J. A., & Fawson, P. C. (2005). An evaluation of two approaches for teaching reading comprehension strategies in the primary years using science information texts. *Early Childhood Research Quarterly*, *20*(3), 276–305. https://doi.org/10.1016/j.ecresq.2005.07.002

Rinehart, S. D., Stahl, S. A., & Erickson, L. G. (1986). Some effects of summarization training on reading and studying. *Reading Research Quarterly*, *21*, 422–438. https://doi.org/10.2307/747614

Rosenshine, B., Meister, C., & Chapman, S. (1996). Teaching students to generate questions: A review of the intervention studies. *Review of Educational Research*, *66*(2), 181–221. https://doi.org/10.3102/00346543066002181

Snow, E. L., Jacovina, M. E., Jackson, G. T., & McNamara, D. S. (2016). iSTART-2: A reading comprehension and strategy instruction tutor. In S. Crossley & D. S. McNamara (Eds.), *Adaptive educational technologies for literacy instruction* (pp. 104–121). Routledge.

Stockard, J. (2010). Promoting reading achievement and countering the "fourth-grade slump": The impact of direct instruction on reading achievement in fifth grade. *Journal of Education for Students Placed at Risk*, *15*(3), 218–240. https://doi.org/10.1080/10824669.2010.495687

van den Broek, P., Beker, K., & Oudega, M. (2015). Inference generation in text comprehension: Automatic and strategic processes in the construction of a mental representation. In E. J. O'Brien, A. E. Cook, & R. F. Lorch, Jr. (Eds.), *Inferences during reading* (pp. 94–121). Cambridge University Press.

Vygotsky, L. S. (2012). *Thought and language*. MIT Press.

Wade-Stein, D., & Kintsch, E. (2004). Summary street: Interactive computer support for writing. *Cognition and Instruction*, *22*(3), 333–362. https://doi.org/10.1207/s1532690xci2203_3

Wexler, N. (2020). *The knowledge gap: The hidden cause of America's broken education system—and how to fix it*. Penguin.

Zwaan, R. A., Langston, M. C., & Graesser, A. C. (1995). The construction of situation models in narrative comprehension: An event-indexing model. *Psychological Science*, *6*(5), 292–297. https://doi.org/10.1111/j.1467-9280.1995.tb00513.x

MORE TO EXPLORE

- To learn more about the science of reading, check out these articles:
  - a 9 Things Science Tells Us about how Kids Learn to Read: https://www.the74million.org/article/9-things-science-tells-us-about-how-kids-learn-to-read-and-think-critically/
  - b The Science of Reading Comprehension Instruction: https://doi.org/10.1002/trtr.1993
- The Knowledge Matters Campaign: https://knowledgematterscampaign.org
- A Presentation by Dr. Danielle McNamara on using Intelligent Tutoring Systems to Improve Literacy: https://www.youtube.com/watch?v=LbX-FfIlqNg