BEST PRACTICES IN ONLINE MATH AND READING INSTRUCTION

July 2020

HANOVER RESEARCH

TABLE OF CONTENTS

INTRODUCTION

In Spring 2020, school districts across the United States closed schools and transitioned to online learning following the onset of the COVID-19 pandemic. A recent report by the World Bank estimates that five months of school closures may decrease the effective years of schooling from 7.9 years to between 7.0 and 7.6 years. Furthermore, nearly seven million K-12 students may drop out of school because of COVID-19's economic impact. These life-long consequences, in addition to the World Bank's other estimates in this report, require quick and careful planning from school districts as well as effective instruction and support from teachers.[1]

To support teachers and staff in the event of ongoing school closures and virtual instruction, Hanover Research (Hanover) presents researched and anecdotal best practices for delivering online math and reading instruction to students in Grades K-12. The report contains two sections:

- **Section I: Online Math Instruction** identifies best practices for teaching math through fully online instruction. This section highlights three strategies to consider at the elementary, middle, and high school levels: facilitating group discussions, using interactive programs, and implementing self-reflection tasks; and
- **Section II: Online Reading Instruction** identifies best practices for teaching reading through fully online instruction. This section highlights three strategies to consider at the elementary, middle, and high school levels: using interactive programs, providing digital texts, and encouraging parent involvement.

RECOMMENDATIONS

Based on our findings, Hanover recommends:

- **Provide professional development around high-leverage, evidence-based math and reading instructional strategies.** For example, support teachers in facilitating online group discussions during synchronous and asynchronous instruction by asking purposeful questions and making real-world connections to develop student understanding, engage all students, and prevent misconceptions.
- **Monitor the use of interactive programs (e.g., Khan Academy) to ensure they supplement—not substitute—quality instruction.** Encourage teachers to identify the intended use of interactive programs and integrate these programs only after careful consideration of the developer's recommendations and general pedagogical best practices.
- **Encourage dialogue among teachers to supplement a limited research base in online reading and math instructional strategies.** Through professional learning communities, discussion boards, or other means of connection, have teachers share what is and what is not working as they learn to navigate a virtual learning environment. Consider collecting and sharing ideas district-wide through the creation of an online resource center or teacher-led virtual workshops.
- **Consider a vendor scan of available computer-based reading and math programs** that could supplement current curricula or facilitate the evidence-based best practices identified in this report.

[1] Azevedo, J.P. et al. "Simulating the Potential Impacts of COVID-19 School Closures on Schooling and Learning Outcomes: A Set of Global Estimates." World Bank Group, June 2020. http://pubdocs.worldbank.org/en/798061592482682799/covid-and-education-June17-r6.pdf

KEY FINDINGS

- **Teachers should continue to engage students in math and reading discussions despite learning in different locations and through non-traditional approaches**. For example, students in elementary, middle, and high school should participate in math-based group discussions, as there is a demonstrated positive impact of discourse on student outcomes and a teacher's ability to monitor student understanding and interest. Teachers can facilitate discussions by asking "why" questions and questions that lead students to explain their or a peer's problem-solving approach. Additionally, literature-based conversations support students during online literacy lessons and can take place with parents and families. These conversations may happen outside of class time and prompt students to think about new topics and read more challenging material.

- **Interactive programs that use videos, games, virtual reality features, or other engaging elements support student learning and engagement but should be used in addition to teacher instruction**. Many teachers who assign interactive programs as the main form of math instruction or flipped classroom lessons may be using the programs incorrectly and against program recommendations. For example, Khan Academy should serve as a supplement to rather than a substitute for teacher-led instruction. However, these programs consistently engage students in learning math and reading concepts according to the available empirical literature and therefore can support positive student outcomes with thoughtful implementation.

- **Digital texts and reading activities allow teachers to expand learning opportunities for students during online instruction.** Students may access these texts through iPod audiobooks, e-Books, website articles, or other tools. Providing digital texts during online learning supports student engagement and interest in both fiction and nonfiction materials. Additionally, teachers can design WebQuests, which provide structure to students' engagement with online texts and prevent students from reading texts that are inapplicable or inappropriate for lessons.

- **Self-reflection during online math instruction supports student development, particularly among middle school and struggling students**. When students spend time on self-reflection, their engagement, confidence, and performance on unit and course assessments may increase. Activities that teachers can assign for self-reflections include journaling, blogging, and posting on asynchronous class discussion boards. Although self-reflection becomes less frequent among older and high-performing students, the process remains important for teaching students to monitor and assess their learning in addition to receiving teacher feedback.

- **Because parents play an instructional and supportive role during online learning, teachers must ensure that parents maintain realistic expectations of students' learning and reading development.** Parent expectations have the most significant impact on student outcomes in terms of parent involvement opportunities. Therefore, parents must believe in and expect a certain level of achievement from their students. During online learning, when students remain at home with their parents, teachers can promote high expectations by relaying individual students' successes to their parents, having parents sign off on learning agendas, and holding parent conferences. However, teachers must ensure that parents do not expect too much of their students during online learning and non-traditional instruction.

SECTION I: ONLINE MATH INSTRUCTION

In this section, Hanover identifies best practices for teaching math at the elementary, middle, and high school levels through fully online instruction. In addition, Figure 1.1 highlights previous Hanover reports about math instructional practices that can be accessed by first logging into the Hanover Digital Research Library and then clicking on the links below. While these reports do not include online-specific practices and strategies, the information therein should be considered for virtual adaptation.

Figure 1.1: Additional Hanover Reports on Math Instruction

Best Practices in Math Instruction for the Upper Elementary Grades	K-5 Math Instruction and Response to Intervention	Best Practices in Accelerated Math Programming	Best Practices in High School Mathematics Interventions

Source: Hanover Research[2]

GROUP DISCUSSIONS

Online synchronous discussions about problem-solving and other math concepts successfully increase students' math performance, particularly on state assessments. At the elementary level, a 2018 study published in *Online Learning* analyzes the impact of synchronous dialogue about math problems on Grade 3, 4, and 5 students' math self-efficacy, confidence, and mindset as well as academic achievement. Results, which draw on 898 students' participation, show that an increase in discourse participation does not necessarily increase math confidence, self-efficacy, and mindset; however, an increase in participation does increase student performance on state assessments. The study identifies the following two outcomes:[3]

- The more sessions students participated in, the higher the probability of scoring at or above Proficient on state assessments, after holding prior achievement consistent; and
- A higher frequency of discourse participation is associated with a higher probability of scoring at or above Proficient on state assessments, regardless of the confidence and self-efficacy level.

Additionally, researchers demonstrate that online synchronous discourse is possible and effective even among students who do not interact with each other outside of the discussion forum setting.[4] This finding may support the use of online discussion forums during COVID-19 school closures even in a new academic year when students may not be familiar with their teacher or peers.

While research regarding online math discussions is limited at the middle-school level, *in-person* math discussions demonstrate the effectiveness of discourse. For example, a 2019 study published in *Mathematics Education Research Journal* analyzes the impact of in-person lessons that intentionally evoke discussions—shift-problem lessons—on student conversations and achievement. The study sample includes 160 Grade 7 students and compares conversations during algebra lessons for students engaging in shift-problem lessons and textbook groupwork. Here, the shift-problem lessons lead to more and higher-quality discussions than

[2] Figure adapted from: [1] "Best Practices in Math Instruction for the Upper Elementary Grades." Hanover Research, January 2020. https://hanoverresearch.secure.force.com/customerportal/sfc/servlet.shepherd/version/download/0681T000008u96AQAQ [2] "K-5 Math Instruction and Response to Intervention." Hanover Research, May 2017. https://hanoverresearch.secure.force.com/customerportal/sfc/servlet.shepherd/version/download/06850000003C8ttAAC [3] "Best Practices in Accelerated Math Programming." Hanover Research, July 2016. https://hanoverresearch.secure.force.com/customerportal/sfc/servlet.shepherd/version/download/068500000040mSvAAI [4] "Best Practices in High School Mathematics Interventions." Hanover Research, August 2016. https://hanoverresearch.secure.force.com/customerportal/sfc/servlet.shepherd/version/download/06850000002KWb1AAG

[3] Preceding information obtained and bulleted text reproduced verbatim from: Choi, J. and A. Walters. "Exploring the Impact of Small-Group Synchronous Discourse Sessions in Online Math Learning." *Online Learning*, 22:4, December 1, 2018. pp. 50, 61–62. https://olj.onlinelearningconsortium.org/index.php/olj/article/view/1511

[4] Ibid., p. 62.

textbook-based conversations as well as improvements in test performance, though both groups improved.[5] High-quality discussions include specific activities that cause reflection and deep thinking. These activities, which occur during shift-problem lessons, appear in Figure 1.2.[6]

Figure 1.2: Discussion Activities that Lead to Productive Conversations

REGULATING ACTIVITIES	MENTAL ACTIVITIES	KEY ACTIVITIES
▪ Student A asks Student B to tell/show their work ▪ Student A asks Student B to explain their work ▪ Student A criticizes Student B's work	▪ Student B becomes aware of their work ▪ Student B thinks about their work ▪ Student B thinks about Student A's criticism ▪ Student B thinks about their justification ▪ Student B criticizes their work	▪ Student B tells/shows their work ▪ Student B explains their work ▪ Student B justifies their work ▪ Student B reconstructs their work

Source: *Mathematics Education Research Journal*[7]

Education organizations also find that math discussions and meetings support math development and note strategies for ensuring productive interactions. Colorado Community College Online provides a presentation on conducting and evaluating online discussions. The presentation, here, includes why and how discussions should occur, a rubric for assessing teacher facilitation, strategies for and challenges of discussions, and other resources.[8] Discussion practices noted by K-12 organizations include but are not limited to:[9]

- Connecting math concepts to real-world situations;
- Asking "why" questions;
- Conducting meetings in a consistent way (i.e., introduction, a brief lesson, feedback and discussion, summary);
- Including multiple chances for interactions; and
- Engaging all students, including English language learners (ELLs).

Asking questions that guide and elicit productive discourse allows teachers to assess students' understanding, confidence, interest, and misconceptions.[10] Figure 1.3 contains examples of questions that teachers may ask to assess these areas and support students.

[5] Calor, S.M. et al. "'Let Us Discuss Math'; Effects of Shift-problem Lessons on Mathematical Discussions and Level Raising in Early Algebra." *Mathematics Education Research Journal*, July 25, 2019. pp. 7-8,17-18. http://link.springer.com/10.1007/s13394-019-00278-x

[6] Ibid., p. 5.

[7] Figure reproduced nearly verbatim from: Ibid.

[8] "The Online Math 'Classroom' – Best Practices for Discussions." Colorado Community Colleges Online, August 23, 2013. http://www.ccconline.org/wp-content/uploads/2013/11/TheOnlineMathClassroom.pdf

[9] Bulleted text adapted from: [1] "Three Tips for Remote Mathematics Instruction." UnboundEd, May 8, 2020. https://blog.unbounded.org/three-tips-for-remote-mathematics-instruction/ [2] Ferlazzo, L. "Math Instruction in the Age of the Coronavirus." Education Week, May 7, 2020. http://blogs.edweek.org/teachers/classroom_qa_with_larry_ferlazzo/2020/05/math_instruction_in_the_age_of_the_coronavirus.html?cmp=SOC-SHR-FB [3] Ferlazzo, L. "'Less Is More' in Math Distance Learning." Education Week, May 8, 2020. http://blogs.edweek.org/teachers/classroom_qa_with_larry_ferlazzo/2020/05/less_is_more_in_math_distance_learning.html?cmp=SOC-SHR-FB [4] Kersaint, G. "Talking Math: How to Engage Students in Mathematical Discourse." Getting Smart, September 29, 2015. https://www.gettingsmart.com/2015/09/talking-math-how-to-engage-students-in-mathematical-discourse/

[10] Kersaint, Op. cit.

Figure 1.3: Questions to Guide Math Discussions

SUPPORT INSTRUCTIONAL DECISION MAKING	DIRECT AND REDIRECT STUDENT FOCUS
▪ Can anyone restate what Student A is trying to say? ▪ I think I know what you are trying to say. Can you think of another way to say that? ▪ Do you agree with Student A's reasoning? ▪ Did anyone get another answer? Did anyone do the problem another way?	▪ Can someone explain Student A's approach in another way? ▪ Does anyone have a different approach? ▪ Does anyone have anything to add to Mark's explanation? ▪ What assumptions did you make when you solved this problem?

Source: Getting Smart[11]

Whether math discourse takes place online or in schools, the National Council of Teachers of Mathematics (NCTM) highlights eight teaching practices for equitable and effective math instruction. This list refers to teachers supporting high-quality, math-based conversations and asking questions.[12] The complete list of NCTM's recommended teaching practices appears in Figure 1.4.

Figure 1.4: The National Council of Teachers of Mathematics' Effective Teaching Practices

	Establish mathematical goals to focus learning		Pose purposeful questions
	Implement tasks that promote reasoning and problem solving		Build procedural fluency from conceptual understanding
	Use and connect mathematical representations		Support productive struggle in learning mathematics
	Facilitate meaning mathematical discourse		Elicit and use evidence of student thinking

Source: National Council of Teachers of Mathematics[13]

INTERACTIVE PROGRAMS

Online instructional games and videos offer interactive learning tools with positive impacts on student learning, particularly when such activities incorporate certain design features and teachers use them appropriately. Through empirical research and interview responses, students in elementary school demonstrate high levels of engagement and interest in math when using game-based activities and following online video lessons. These studies highlight how independent, online activities support student math development *in addition to* teacher-based instruction.[14] Figure 1.5 summarizes the impact of online learning programs with interactive games and assessments on student performance.

[11] Figure reproduced nearly verbatim from: Ibid.
[12] Soumeillan, B. "Research-Based Tips to Turn Up Math Talk." ASCD, July 26, 2018. http://www.ascd.org/ascd-express/vol13/1322-soumeillan.aspx
[13] Figure text reproduced verbatim from: "Moving Forward: Mathematics Learning in the Era of COVID-19." National Council of Teachers of Mathematics, June 2020. p. 9. https://www.nctm.org/uploadedFiles/Research_and_Advocacy/NCTM_NCSM_Moving_Forward.pdf
[14] [1] Yeh, C.Y.C. et al. "Enhancing Achievement and Interest in Mathematics Learning through Math-Island." *Research and Practice in Technology Enhanced Learning*, 14:1, December 2019. https://link.springer.com/content/pdf/10.1186/s41039-019-0100-9.pdf [2] Hollands, F.M. and Y. Pan. "Evaluating Digital Math Tools in the Field." *Middle Grades Review*, 4:1, 2018. https://files.eric.ed.gov/fulltext/EJ1175679.pdf [3] Berrett, A.N. and N.J. Carter. "Imagine Math Facts Improves Multiplication Fact Fluency in Third-Grade Students." *Journal of Behavioral Education*, 27:2, June 2018. http://link.springer.com/10.1007/s10864-017-

Figure 1.5: Research Supporting Online Math Programs

AUTHORS (YEAR)	PURPOSE	SAMPLE	RESULTS
Yeh et al. (2019)[15]*	To study the impact of Math Island, a game-based learning program, on elementary school students' math achievement (i.e., "conceptual understanding, calculating, and word problem-solving") as well as interest among low-performing students in math and the program over two years	Test group: 215 Grade 2 students; Control group: 125 Grade 2 students	▪ Math Island positively and statistically significantly impacts students' calculating and word problem-solving skills, but not conceptual understanding ▪ Math Island strongly supports low-performing students' word problem-solving skills ▪ Low- and high-performing students demonstrate greater interest in math than students not using Math Island ▪ Elementary school students can learn through self-guided approaches
Hollands and Pan (2018)[16]	To study the impact of IXL and eSpark, two interactive learning programs, on math test scores and each program's value concerning resource and monetary requirements	99 pairs of matched students from a test group of 105 Grade 3-5 students and 198 Grade 3-5 students in one district	▪ eSpark costs 4.5 times more than IXL but leads to higher student scores on math assessments ▪ Programs have high operating costs and marginal costs per student, which do not significantly decrease after initial implementation ▪ Teacher time dedicated to reviewing program analytics varies but represents another cost if teachers thoroughly review program materials and data ▪ Costs to teacher time can decrease if teachers use the program as a teaching substitute rather than a supplement, but this method may negatively impact student learning
Berrett and Carter (2017)[17]	To study the impact of Timez Attack, a computer-assisted math fact fluency program, on elementary school students' multiplication fact fluency	63 Grade 3 students divided into three testing groups that use the program for different amounts of time	▪ Students using Timez Attack improved math fact fluency consistently once starting and after ending the program ▪ Students find the program engaging and fun due to the game-like activities ▪ Timez Attack's computer-adaptive technology allows students to keep practicing incorrect responses (which provide visual feedback) until consistent success and move to a new concept after demonstrating mastery
Kiger et al. (2012)[18]	To study the impact of a Mobile Learning Intervention (MLI) that uses iPod applications on student achievement compared to other variables	Test group: 41 Grade 3 students and two teachers; Control group: 46 Grade 3 students and two teachers	▪ Students with the MLI performed better than the control group on a multiplication posttest ▪ The study's MLI demonstrates a cost-effective option compared to other individual strategies such as one-to-one computers or supports that require additional software or hardware ▪ Other variables that explain student improvement include student demographics and teacher training, which lead researchers to suggest in-class MLIs

Sources: Multiple sources cited within the figure.
*This study reflects an international population.

9288-1 [4] Kiger, D., D. Herro, and D. Prunty. "Examining the Influence of a Mobile Learning Intervention on Third Grade Math Achievement." *Journal of Research on Technology in Education*, 45:1, September 2012. https://files.eric.ed.gov/fulltext/EJ991839.pdf

[15] Yeh et al., Op. cit., pp. 1, 8–9, 16–17.
[16] Hollands and Pan, Op. cit., pp. 1, 4, 12–13.
[17] Berrett and Carter, Op. cit., pp. 223, 227, 234–237.
[18] Kiger, Herro, and Prunty, Op. cit., pp. 61–67, 76–77.

Specific program design features may also enhance online math program effectiveness. For example, virtual reality components of online learning programs should ensure that actions (e.g., opening a door, moving objects) are clear and do not assume that students immediately understand a situation. Additionally, these programs should include a mission or challenges with rewards as well as goals to increase engagement and interest in learning.[19]

For online learning programs that do not necessarily include a virtual reality component, four general design features demonstrate repeated success in supporting students with representing math problems: Representation Practice, Represent It, Image-Enhanced Problems, and Image-Enhanced Hint. Figure 1.6 contains descriptions, benefits, and liabilities of these features, as presented in a 2016 conference paper on online learning programs' design patterns.[20]

Figure 1.6: Design Patterns that Support Online Math Programs

FEATURE	DESCRIPTION	BENEFITS	LIABILITIES
Representation Practice	Ask students to answer practice problems that require them to use different representations so they gain experience and hone their skills in selecting, applying, and utilizing appropriate representations.	▪ Practice problems give students opportunities to learn about many different representations. ▪ Practice helps to build memory and fluency, which facilitates the recall of different representations.	▪ Teachers need to design and implement various practice problems on the online learning system for students to learn from. ▪ Students who continuously fail to answer problems may lose motivation. They may be more likely to give up when asked to solve similar problems. Worked examples or feedback may be needed to support learning. ▪ It takes time for students to learn and master skills for representing problems and solutions.
Represent It	Encourage students to externalize their thoughts using representations to help them better understand the problem and figure out the answer	▪ Externalizing the elements of the problem frees up the working memory making it easier to process information. ▪ Compared to mental representations, it is easier to locate and address errors in externalized representations because they can be seen explicitly. Externalizing representations also frees up working memory, which facilitates focused processing. ▪ Students are better able to perform metacognitive tasks with less cognitive load. Metacognition helps students evaluate, assess, and revise their learning strategies.	▪ The online learning system needs to support feedback mechanisms to use the pattern (e.g., hint messages). ▪ The student should have some prior knowledge on using the representation otherwise they would not be able to use it. ▪ In some cases, there may be multiple representations that lead towards the problem's solution. The optimal order and necessary types of representations that are created and used may vary by student

[19] Xu, X. and F. Ke. "Designing a Virtual-Reality-Based, Gamelike Math Learning Environment." *American Journal of Distance Education*, 30, 2016. p. 36. https://www.researchgate.net/publication/295242270_Designing_a_Virtual-Reality-Based_Gamelike_Math_Learning_Environment

[20] Inventado, P.S. and P. Scupelli. "Design Patterns for Helping Students to Learn to Represent Math Problems in Online Learning Systems." Proceedings of the 21st European Conference on Pattern Languages of Programs - EuroPLoP '16, 2016. pp. 1, 5. http://dl.acm.org/citation.cfm?doid=3011784.3011816

FEATURE	DESCRIPTION	BENEFITS	LIABILITIES
Image-Enhanced Problem	Clarify ambiguous terms and explanations in the math problem by adding appropriate images.	▪ Images can succinctly illustrate concepts that may clarify and disambiguate confusing terms and explanations. ▪ Students can focus their mental effort on solving the problem after they disambiguate terms and explanations. ▪ Clear and simple images can help students understand the problem quickly, which leaves them more time to solve it. ▪ Students are less likely to solve for something unrelated when they have a clear understanding of the problem. ▪ Well-designed images can express ideas concisely that will allow students to focus on the important elements of the problem.	▪ It takes more time and effort to create appropriate images for each problem. ▪ Some ideas, such as abstract concepts, are difficult to illustrate. ▪ Images take a longer time to load over the network compared to text. ▪ Images may not always appear on the screen as intended due to uncontrollable factors (e.g., screen size, color and screen resolution supported, image loading is disabled in the browser).
Image-Enhanced Hint	Clarify hints for math problems by adding images that help to disambiguate confusing terms and explanations.	▪ Images can succinctly disambiguate confusing terms and explanations in the hints. ▪ Students can focus their mental effort on understanding the intention of the hint after they disambiguate terms and explanations. ▪ Well-designed images can express ideas concisely that will allow students to focus on the important elements of the hint. ▪ Clear hints are more likely to help students and motivate them to solve the problem. ▪ Students are less likely to solve for something unrelated when they have a clear understanding of the hint.	▪ It takes more time and effort to create appropriate images for hints. ▪ Some ideas, such as abstract concepts, are difficult to illustrate. ▪ Images take a longer time to load over the network compared to text. ▪ Images may not always appear as intended due to uncontrollable factors (e.g., screen size, color and screen resolution supported, image loading is disabled in the browser).

Source: *EuroPLoP '16*[21]

Furthermore, when implementing an online math program to support instruction, teachers must ensure that they use the program for its intended purpose. Using programs differently than prescribed works against intended outcomes, even if they maintain student interest and engagement in math activities and practice. For example, a 2015 journal article on the use of Khan Academy notes that teachers often do not use the tool as Salman Khan, the founder and executive director, recommends.[22] Rather than using the program "to personalize instruction, freeing up class time for engaging high yield activities like student discourse and meaningful collaborative projects," teachers often use Khan Academy for flipped-classroom instruction in middle and high schools.[23] Student interviews show that Khan Academy engages learners, and the program offers a more fun approach to math instruction; however, students report that teachers that use Khan Academy do not all differentiate instruction, review program data, or assign highly collaborative projects to supplement videos, as suggested.[24]

[21] Figure text reproduced verbatim from: Ibid., pp. 5–7, 9–10, 12–13, 15–16.
[22] Cargile, L. and S. Harkness. "Flip or Flop: Are Math Teachers Using Khan Academy as Envisioned by Sal Khan?" *TechTrends: Linking Research & Practice to Improve Learning*, 59:6, November 2015. p. 21. Retrieved from EBSCOhost.
[23] Ibid.
[24] Ibid., pp. 23–25.

Using Khan Academy or similar programs other than as intended also conflicts with NCTM-recommended instructional approaches, which include:[25]

- Active learning strategies;
- Explorations;
- Differentiated pacing;
- Interesting and work-related projects; and
- Activities incorporating communication to promote learning for understanding.

SELF-REFLECTION TASKS

Students benefit from self-reflection regarding math concepts and individual understanding. Through online learning-based self-reflection, students demonstrate high engagement and increasing confidence levels. Additionally, the more frequently students engage in reflection, the higher they perform on unit and course assessments.[26] Researchers identify these outcomes in a study published in *Online Learning* that uses a 283-student pilot sample and a 2,050-student extended study sample with elementary, middle, and high school students. Researchers analyze the impact of self-reflection on math self-confidence and performance in an online setting.[27] Self-reflection assessments and response data demonstrate the following outcomes across grade levels:[28]

- Students remain highly engaged in online self-reflections;
- Students' math confidence increases over time according to responses;
- Students with higher self-assessed skill levels received higher test results; and
- Students who engage in reflection more often also perform better in a course.

Elementary and middle school students tend to engage in reflection more frequently than high school students, and high school students demonstrate a significant decrease in reflection participation over time. **Middle school students, though, demonstrate the strongest connection between self-reflection engagement and academic performance for all units in a course**.[29] Additionally, low-performing students often engage in self-reflection assessments more frequently than high-performing students, and students in the most difficult courses tend not to complete self-reflection assessments. An explanation for this outcome, other than research methods and unobserved factors, is that "as students grow older and become better in their understanding of more difficult math topics, they tend to skip supplementary learning opportunities such as reflection assessments."[30]

The researchers highlight that effective self-reflection must be differentiated, and teachers must be aware of how self-reflection can take place online (e.g., journaling, asynchronous discussion groups, blogging). Reflection exercises may include opportunities that range from open-ended responses to content-focused review.[31] To support students' self-reflection, teachers may use templates and guides found online. Online resources include free and purchasable tools that apply to all students or specific grade levels. The Oregon Department of Education provides strategies for engaging students in self-reflection and self-assessment in a presentation here.[32] This presentation also includes examples of elementary-level self-reflection worksheets, a group assessment template, methods for teaching self-assessment, and, as shown in Figure 1.7,

[25] Bulleted text reproduced nearly verbatim from: Ibid., p. 26.
[26] Choi, J., A. Walters, and P. Hoge. "Self-Reflection and Math Performance in an Online Learning Environment." *Online Learning Journal*, 21:4, December 1, 2017. pp. 88–91. https://www.learntechlib.org/p/183779/
[27] Ibid., p. 95.
[28] Bulleted text adapted from: Ibid., pp. 88–91.
[29] Ibid., p. 92.
[30] Ibid., pp. 95–96.
[31] Ibid., pp. 97–98.
[32] "Teaching Students Self-Assessment: Activity 5.10." Oregon Department of Education. https://www.oregon.gov/ode/educator-resources/assessment/Documents/teaching_students_self-assessment.pdf

strategies for self-assessments that teachers may use immediately.[33] Although these strategies contain in-class supports, teachers may apply them to online instruction.

Figure 1.7 Strategies for Engaging Students in Self-Assessments

	Ask students to highlight the best section of their work and explain why they think it is the best		Teach and model self-assessment
	Have students identify where they have met each of the Success Criteria		Provide exemplars so that students know what they are aiming for
	Ask students to highlight the sentence or section of their work that they are most pleased with and tell you why		Ask students to identify an area where they are uncertain and what help they need
	Ask students to write one question they would like you to answer in your feedback		Use one of the self-assessment templates or design some yourself
	Pause during the lesson and ask students to discuss how their learning is going		Introduce exit cards where students write and submit answers to prompts such as: *What was the most important thing you learned today? What questions do you still have?*
	Provide some sentence starters and prompts to help students think about their learning and identify areas for improvement		Use 3,2,1 at the end of a lesson: *3 things I learned, 2 questions I have, 1 insight I had*

Source: Oregon Department of Education[34]

[33] Ibid.
[34] Figure text reproduced nearly verbatim from: Ibid., pp. 18–19.

SECTION II: ONLINE READING INSTRUCTION

In this section, Hanover identifies best practices for teaching reading at the elementary, middle, and high school levels through fully online instruction. Figure 2.1 links to previous Hanover reports with reading instructional practices, and, as in Section I, these reports do not include online-specific practices and strategies, although teachers should consider adapting these best practices for online instruction depending on students' needs and comfort with online instruction platforms. These reports may be accessed by logging into the Hanover Digital Research Library and clicking on the links below.

Figure 2.1: Additional Hanover Reports on Reading Instruction

Best Practices for Literacy Instruction in the Primary Grades	Impact of Oracy on Literacy Development	Effective School-Wide Literacy Strategies for Secondary Students	Improving K-5 Literacy Outcomes

Source: Hanover Research[35]

INTERACTIVE PROGRAMS

Game-based activities and interactive tools demonstrate success in supporting students with reading and writing, though research is limited. Similar to math instruction, content-focused applications and creative tasks appear to enhance reading skills and engage students. For example, a 2011 international study from the *Journal of Language Teaching and Research* analyzes the impact of WebQuests on ELLs' reading development and engagement.[36] WebQuest creators define this tool as:[37]

> "a scaffold learning structure that uses links to essential resources on the World Wide Web and an authentic task to motivate students" investigation of a central, open-ended question, development of individual expertise and participation in a final group process that attempts to transform newly acquired information into a more sophisticated understanding. The best WebQuests do this in a way that inspires students to see richer thematic relationships, facilitate a contribution to the real world of learning and reflect on their own metacognitive processes."

Following WebQuest assignments, 44 university students demonstrate increased reading skills and find WebQuests useful, interesting, and motivating.[38]

When incorporating WebQuests, American Library Association contributors recommend carefully reviewing these activities before implementation. Pre-made WebQuests may include broken links, inappropriate websites, inapplicable content, or low-quality information.[39] Figure 2.2 contains guiding questions to support teachers in choosing WebQuests.

[35] Figure adapted from: [1] "Best Practices for Literacy Instruction in the Primary Grades." Hanover Research, June 2018. https://hanoverresearch.secure.force.com/customerportal/sfc/servlet.shepherd/version/download/06850000005656nAAA [2] "Impact of Oracy on Literacy Development." Hanover Research, April 2016. https://hanoverresearch.secure.force.com/customerportal/sfc/servlet.shepherd/version/download/068500000040o6dAAA [3] "Effective School-Wide Literacy Strategies for Secondary Students." Hanover Research, April 2015. https://hanoverresearch.secure.force.com/customerportal/sfc/servlet.shepherd/version/download/06850000001rriOAAQ [4] "Improving K-5 Literacy Outcomes." Hanover Research, January 2015. https://hanoverresearch.secure.force.com/customerportal/sfc/servlet.shepherd/version/download/06850000001phtjAAA

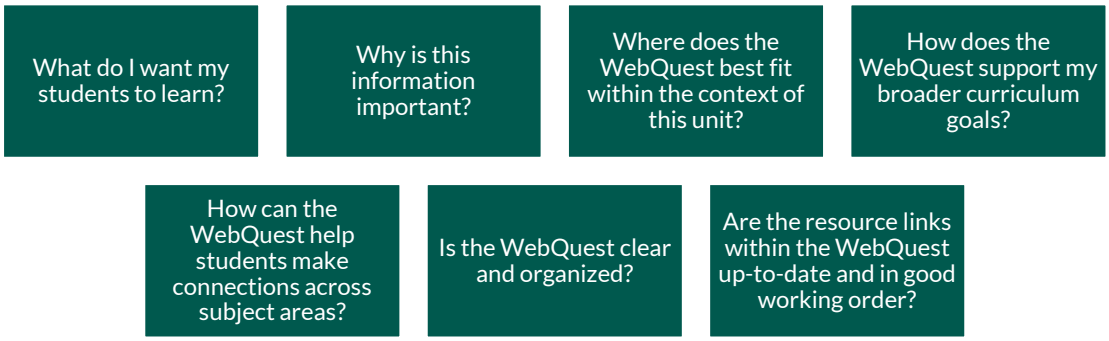
[36] Luu, T.T. "Teaching Reading through WebQuest." *Journal of Language Teaching & Research*, 2:3, May 2011. pp. 664, 668. Retrieved from EBSCOhost.

[37] Block quote reproduced verbatim from: Ibid., pp. 664, 666.

[38] Ibid., pp. 669–671.

[39] Mangelson, J. and J. Castek. "Thinking Outside the Book: Engaging Students with WebQuests." American Library Association, July 2008. http://www.ala.org/aboutala/offices/resources/thinking_outside_the_book

Figure 2.2: Guiding Questions for Choosing WebQuests



Source: American Library Association[40]

Teachers may also find reading and writing applications useful and engaging, though these resources may not provide as much instruction and support as students need. Teachers often use reading games and applications to target phonics, vocabulary, sight words, and other reading skills, but "digital-literacy experts caution that there's a difference between using games and having students do authentic online reading."[41] Rather than using online tools that focus on individual skills, the following resources may provide more applicable, authentic tools:[42]

- Blogs;
- Social media;
- Movie-making apps;
- Bookmarking tools;
- Audio recorders;
- Virtual bulletin boards; and
- Annotating tools.

Spotlight: LightSail

As technology becomes more integrated in K-12 coursework, an Education Week article reports on integrating online resources when teaching texts, specifically *Macbeth*. The article highlights the application LightSail as a useful resource for engaging in literature.[43] This application includes an annotation tool and quizzes as well as computer-adaptive technology that matches students with texts that fit specific interests. The application also collects data on how long students spend on each page of a text. However, teachers and students previously reported issues with getting logged out unintentionally and disliking assessment questions.[44]

DIGITAL TEXTS

Providing students with reading materials and resources enables successful remote reading instruction through traditional and innovative means. Teachers use a variety of materials, such as iPods, hard copy books, and online tools, such as e-Books and applications, to develop students' reading skills.[45] A 2018 study published in *Networks: An Online Journal for Teacher Research* analyzes how using iPods to listen to audiobooks, individually and with family members, impacts literacy development. The study, conducted through action research by a kindergarten teacher, uses a sample of 16 kindergarten students and rotates four iPod shuffles

[40] Figure text reproduced verbatim from: Ibid.
[41] Heitin, L. "How Should Reading Be Taught in a Digital Era?" *Education Week*, November 9, 2016. https://www.edweek.org/ew/articles/2016/11/09/how-should-reading-be-taught-in-digital-era.html
[42] Bulleted text reproduced verbatim from: Ibid.
[43] [1] "Literacy Platform To Promote Literacy Growth & Reading Stamina." LightSail. https://lightsailed.com/ [2] Herold, B. "Teaching Shakespeare With 21st-Century Technology." *Education Week*, November 4, 2016. https://www.edweek.org/ew/articles/2016/11/09/teaching-shakespeare-with-21st-century-technology.html
[44] Herold, Op. cit.
[45] [1] Hover, A.B. "Shuffle Lit!: Using IPod Shuffles to Encourage Literacy Experiences at Home." *Networks: An Online Journal for Teacher Research*, 20:2, August 1, 2018. https://newprairiepress.org/networks/vol20/iss2/4 [2] Barrett, L. "Remote Learning Doesn't Mean Reading Needs to Become One-Size-Fits-All." WeAreTeachers, March 31, 2020. https://www.weareteachers.com/teaching-reading-remotely/

containing 29 audiobooks among them.[46] iPod logs, student interviews, and parent surveys show that using iPods for reading content and remote literacy development "helped to encourage literacy experiences" at home, and students enjoy the audiobooks.[47] Figure 2.3 contains findings from parent surveys as presented in the study.

Figure 2.3: Results from Using iPods to Support Kindergarten Literacy

PROS	CONS
▪ Improved vocabulary ▪ Encouraged reading; helped introduce books to children ▪ Encouraged imagination ▪ Improved listening skills ▪ Offered a resource for independent work ▪ Provided a sense of accomplishment upon completion ▪ Reinforced reading skills learned at school ▪ Promoted independence and allowed students to choose stories ▪ Provided a variety of appropriate, enjoyable stories ▪ Offered different narrators ▪ Some students could easily operate the iPods ▪ Music engaged students more ▪ Exposed students to books they did not have at home ▪ Encouraged students and helped eliminate distractions; students were more focused ▪ Provided family bonding time; students listened with family members using earbuds ▪ Offered cues to aid in learning to read ▪ Helped students to understand stories through pictures and audio ▪ Helped students read tricky words	▪ A few students struggled to listen due to short attention spans ▪ Some students could not operate iPods without help ▪ One student took home an empty iPod, and the teacher had to reload stories ▪ Sometimes, it was difficult to determine which stories the students already heard ▪ Sometimes, it was hard to match the audio stories to the books ▪ A few of the stories were read too quickly; it was hard for the students to follow ▪ Several students were frustrated with the earbuds ▪ Some students needed more time to complete the project (especially ELLs) ▪ Stories were recorded at different audio levels; adjusted volume before each story

Source: *Networks: An Online Journal for Teacher Research*[48]

Digital texts also demonstrate effectiveness through e-Books, which serve as engaging and effective learning materials. For example, a 2012 Canadian study published in the *Journal of Research on Technology in Education* analyzes how e-Books impact student outcomes, including pre- and posttest scores and reading enjoyment. Comprehension tests, motivation questionnaires, reading logs, and observations for six Grade 1 students show that e-Books increase student preference for digital texts compared to print texts, and students seek out e-Books in their free time at home. Additionally, e-Books improve student engagement and development outcomes, as shown in Figure 2.4.[49]

[46] Hover, Op. cit., pp. 3–5.
[47] Ibid., p. 9.
[48] Figure reproduced nearly verbatim from: Ibid., p. 10.
[49] Ciampa, K. "ICANREAD: The Effects of an Online Reading Program on Grade 1 Students' Engagement and Comprehension Strategy Use." *Journal of Research on Technology in Education*, 45:1, September 2012. pp. 27, 51. http://www.tandfonline.com/doi/abs/10.1080/15391523.2012.10782596

Figure 2.4: Impacts of e-Books on Grade 1 Students' At-Home Reading

ENGAGEMENT	READING DEVELOPMENT
▪ Students maintain motivation and engagement in reading when given a choice of reading materials ▪ The choice of reading materials and interest in reading leads to voluntary e-Book reading at home ▪ A selection of fiction and nonfiction texts through digital resources supports student motivation ▪ Student interest in reading increases with interactive features of digital texts (e.g., read aloud options, highlighted text, feedback)	▪ Interactive features may increase comprehension skills as students can focus on comprehension rather than decoding ▪ Interactive features support vocabulary skills for young and struggling students ▪ Interactive features include questions with instant feedback, which improve engagement and mastery ▪ Interactive features allow students to engage with the text while reading aloud, which supports comprehension

Source: *Journal of Research on Technology in Education*[50]

Additionally, because reading continues to shift to technology-based platforms (e.g., e-books, websites, social media), **education professionals highlight that reading and literacy instruction should include print, digital, fiction, and nonfiction texts**.[51] Applications for devices and curated lists of websites provide students with instant resources. For example, Education Week presents websites for nonfiction reading in an article here.[52]

Because real-world applications of reading and writing often occur online and through technology, reading instruction should develop and incorporate digital literacy skills. To teach students how to use and learn from digital texts appropriately, teachers must model appropriate use of various resources and explain how to use new aspects of technology or a specific tool.[53] However, students often acclimate to technology resources quickly, as "today's teenagers are often referred to as 'digital natives.'"[54]

Teachers may further support online reading instruction by teaching how to manage reading and research using online resources and tools. As demonstrated in the iPod study above, technology-based reading and literacy opportunities greatly engage students in texts and literacy skills.[55] However, the nearly endless availability of online reading resources requires teachers to guide students in learning how to stay focused or explore their interests through digital texts. Teachers may support students' focus and regulation through the following strategies:[56]

- Creating webpages with lists of pre-approved sites; and
- Choosing a website with articles and information on a variety of topics and allowing students to select articles and resources to read within a set timeframe.

PARENT INVOLVEMENT

Parent involvement in their student's general and reading education supports learning because of parents' ability to maintain high learning expectations and facilitate engagement in reading. According to a 2019 meta-analysis on the impact of parent involvement in students' academic outcomes across socio-economic statuses, parents' academic expectations have the most significant impact on student performance among parent involvement opportunities.[57] Additional factors include parents' support of learning, talking to their

[50] Figure adapted from: Ibid., pp. 51–54.
[51] Heitin, Op. cit.
[52] Ibid.
[53] Ibid.
[54] Herold, Op. cit.
[55] Hover, Op. cit., p. 10.
[56] Preceding and bulleted text adapted from: Heitin, Op. cit.
[57] Takabori, A. "Six Research-Backed Strategies for Remote Teaching - The Science of Learning Blog." Scientific Learning, April 16, 2020. https://www.scilearn.com/six-research-backed-strategies-for-remote-teaching/

students about school, involvement in school events, parents and students reading together, and parents' emphasis on education.[58] High parent expectations are important because:[59]

- Children may internalize their parents' valuation of achievement;
- Parental expectations may shape children's perceptions of their academic abilities and self-efficacy;
- Parents with higher levels of academic expectations may be more involved in their children's learning; and
- Teachers may be more motivated to facilitate learning in children whose parents have higher academic expectations.

Teachers can influence at-home expectations through the strategies in Figure 2.5.

Figure 2.5: Strategies for Increasing Parent Expectations of Student Performance

Highlight student achievements to parents, along with an explanation of the long-term impact of these achievements	Have parents sign off on daily agendas that describe assignments as well as their learning aims	Arrange weekly virtual chats with parents

Source: Scientific Learning[60]

Additionally, **teachers must encourage parent involvement as parents serve as a resource for conversation and support outside of teacher-led instruction**. Parents and teachers can work together to support reading skills by promoting and implementing strategies described by a Harvard Graduate School of Education professor shown in Figure 2.6.

Figure 2.6: Strategies for Continuing Reading Development Outside of Class Time

HAVE CONVERSATIONS	PROVIDE CHALLENGING TEXTS	FIND OPPORTUNITIES FOR WRITING
Ensure not only that children have access to books, but also that they have access to conversations—someone to prompt their thinking through questions and discussions: ▪ For the youngest readers: read to them and talk with them about the text. ▪ For beginning readers: read with them, alternating reading paragraphs or pages, and talk with them about the text. ▪ For older readers of chapter books or young adult novels: read the same books so you can talk with them about the text.	While children should be encouraged to read for pleasure, it's also important to ensure they are being challenged (encountering new words and more complex ideas and themes) to ensure their literacy skills continue to develop. This encouragement may take the shape of finding a book that parents or an older sibling might want to read and discuss.	Figure out a topic your child is really interested in and suggest a little research project, with a final write-up, poster, slideshow presentation, or performance of what they learned.

Source: Harvard Graduate School of Education[61]

[58] Tan, C., M. Lyu, and B. Peng. "Academic Benefits from Parental Involvement Are Stratified by Parental Socioeconomic Status: A Meta-Analysis." *Parenting*, December 2019. p. 19. https://www.researchgate.net/publication/337927624_Academic_Benefits_from_Parental_Involvement_are_Stratified_by_Parental_Socioeconomic_Status_A_Meta-analysis
[59] Bulleted text reproduced nearly verbatim from: Ibid., p. 21.
[60] Figure text reproduced verbatim from: Takabori, Op. cit.
[61] Figure text reproduced nearly verbatim from: Boudreau, E. "Talk About the Text." Harvard Graduate School of Education, March 18, 2020. https://www.gse.harvard.edu/news/uk/20/03/talk-about-text

APPENDIX

The following table presents materials and tools that teachers may use to inform online teaching or for engaging students in online math and literacy instruction. Each source has an icon to indicate its use as a math or reading resource. Websites provide tools such as activities, learning modules, readings, and games that reach students across the K-12 spectrum. Although some websites identify specific grades to which particular resources apply, others offer general math and/or general reading tools. Teachers may explore using these resources directly or using them as guides for creating new activities.

Figure A. 1: Additional Online Resources

SUBJECT	SOURCE	DESCRIPTION OF RESOURCE	GRADE LEVEL	LINK
	American Library Association[62]	Provides links to websites containing literature-based WebQuests	K-12	
	Association of Mathematics Teacher Educators[63]	Provides links to YouTube tutorials that explain how to facilitate synchronous teaching strategies as well as links to other tutorials for general and math-specific online teaching	K-12	
	Georgia Department of Education[64]	Provides unit-by-unit resource guide for Grades K-8 and high school math content areas based on state curriculum standards	K-12	
	Mississippi Department of Education[65]	Provides descriptions of and links to online resources for math, reading, and other content areas that teachers may use to support summer and academic year learning	PreK-12	
	National Council of Teachers of Mathematics[66]	Provides access to activities—which include the necessary information for supporting implementation—webinars, and a link to a membership free trial with the organization	PreK-12	
	PBIS Rewards[67]	Provides descriptions of and links to online content-based resources for teachers and parents	K-12	
	State of New Jersey[68]	Provides links to online content resources (e.g., narrated instructional videos, interactive games, activities)	K-12	
	Reading Rockets[69]	Provides lists of free and priced literacy applications divided by topic (e.g., comprehension, phonics, print awareness, vocabulary)	PreK-5	

Source: Multiple sources cited within the figure.

[62] Mangelson and Castek, Op. cit.
[63] "Online Teaching Strategies for MTEs: AMTE Rapid Response." Association of Mathematics Teacher Educators. https://amte.net/resources/onlinestrategies
[64] "Introduction to Mathematics Learning Resources." Georgia Department of Education. https://www.gadoe.org/Curriculum-Instruction-and-Assessment/Curriculum-and-Instruction/Documents/Mathematics/GADOE-Remote-Learning-Supplemental-Resources-for-Mathematics-K-12.pdf
[65] "Learning-at-Home Resources for Districts." Mississippi Department of Education. https://www.mdek12.org/covid19/districtresources#English%20Language%20Arts%20Resources
[66] "Free Resources for Teaching Math Online." National Council of Teachers of Mathematics, March 17, 2020. https://www.nctm.org/freeresources/
[67] "Online Learning Resources." PBIS Rewards, July 10, 2020. https://www.pbisrewards.com/resources/online-learning/
[68] "Teacher Resources for Remote Instruction." State of New Jersey, May 7, 2020. https://www.nj.gov/education/covid19/teacherresources/teacherresources.shtml
[69] "Literacy Apps." Reading Rockets. https://www.readingrockets.org/literacyapps

ABOUT HANOVER RESEARCH

Hanover Research provides high-quality, custom research and analytics through a cost-effective model that helps clients make informed decisions, identify and seize opportunities, and heighten their effectiveness.

OUR SOLUTIONS

ACADEMIC SOLUTIONS

- College & Career Readiness:
  Support on-time student graduation and prepare all students for post-secondary education and careers.
- Program Evaluation:
  Measure program impact to support informed, evidence-based investments in resources that maximize student outcomes and manage costs.
- Safe & Supportive Environments:
  Create an environment that supports the academic, cultural, and social-emotional needs of students, parents, and staff through a comprehensive annual assessment of climate and culture.

ADMINISTRATIVE SOLUTIONS

- Family and Community Engagement:
  Expand and strengthen family and community relationships and identify community partnerships that support student success.
- Talent Recruitment, Retention & Development:
  Attract and retain the best staff through an enhanced understanding of the teacher experience and staff professional development needs.
- Operations Improvement:
  Proactively address changes in demographics, enrollment levels, and community expectations in your budgeting decisions.

LEADERSHIP SOLUTION

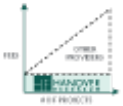
Build a high-performing administration that is the first choice for students, parents, and staff.

OUR BENEFITS

EXPERT
200+ analysts with multiple methodology research expertise

FLEXIBLE
Ongoing custom research agenda adapts with organizations' needs

DEDICATED
Exclusive account and research teams ensure strategic partnership



EFFICIENT
Annual, fixed-fee model shares costs and benefits

HANOVER RESEARCH

www.hanoverresearch.com