Developing Student Mathematics Skills: How *Study Island* Aligns with Best Practice

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Many would agree that mathematical proficiency is a critical lifelong skill. However, recent studies suggest that the importance of mathematics to students varies based upon the perceived value and support from teachers, parents, and peers.[1] National test results from the National Assessment of Educational Progress (NAEP) confirm that 60-65% of fourth- and eighth-grade students in the United States lack mathematics proficiency, and they rank 32nd internationally in mathematics understanding.[2,3] By creating a learning environment where students understand the value of math as a lifelong skill, educators are better able to promote positive student attitudes and learning. Specifically, research-based practices in instructional strategies and student assessment offer practical solutions for establishing a classroom climate that supports and values math learning at high levels.

The research base on instructional strategies and student assessment indicates that programs that incorporate these best practices can positively influence student math outcomes (see Appendix for effect sizes). This white paper presents evidence-based strategies that improve student math achievement and outlines how one online K-12 learning program, *Study Island*, integrates these practices.

Instructional Strategies

Several research-based instructional practices are associated with math achievement, including varying methods of instructional delivery, increasing student motivation, and providing distributed and focused practice.

1. *Varying methods of instructional delivery*. When it comes to learning, there is a wide variety of instructional options based on student learning styles for acquiring information. By accommodating different learning styles, teachers positively influence student math achievement and attitudes.[4,5] For example, research suggests that video and animations are a beneficial instructional tool. Learning math content from animations has a greater impact on math learning and understanding compared to learning concepts through static images (e.g., textbook images).[6,7] However, not all students prefer animations. Research shows that students' beliefs about learning influence their choices for different instructional modalities (i.e., text, video, animation).[8] This reinforces the importance of integrating multiple instructional tools and methods into math instruction so that students benefit from an optimal learning environment tailored to meet their needs.

HOW STUDY ISLAND INCORPORATES RESEARCH-BASED INSTRUCTIONAL STRATEGIES IN MATH

- Contains interactive activities, videos and animations within math lessons and content review
- Assesses students on their understanding and mastery of material and provides a sense of academic support
- Allows teachers to decide the frequency and amount of practice for their students and provides focused practice that tailors instruction to student ability level

2. *Improving student motivation in math*. Research shows that students who are engaged or motivated have greater math achievement than students who are not and that early math achievement is a predictor of motivation in math one to two years later.[9,10] Student perceptions of the presence of academic support (i.e., teacher cares about student learning), being assessed for understanding of material, and teachers' concern of student content mastery are all positively related to student motivation for mastery in math.[11]
When teachers take time to acknowledge and support motivation in the classroom, students achieve math learning gains.

3. *Providing distributed and focused math practice*. Over 100 years of research into the nature of learning suggests that students learn more when they distribute learning over time rather than learning in one massed session (i.e., cramming).[12] Distributed learning over an eight- to 30-day period and having at least one day between learning sessions is beneficial for retention of math skills and increases final math achievement by 29%.[13] This is particularly relevant for complex math skills, which require practice or review over multiple days to achieve greater retention.[14]

Not only does the amount of time students spend learning complex skills have an impact on their math achievement but so does the specific type of practice or review activity. More complex and challenging math skills require more focused practice than basic math skills. Focused practice breaks out complex skills into subskills so that learning is incremental and targeted.[15] The National Council of Teachers in Mathematics (NCTM) supports the use of focused practice, suggesting that teachers present math concepts together and build math concepts off each other.[16] Research also supports focused practice as a proven strategy that promotes math learning. Students who have opportunities to practice math content at lower levels and progressively increase content review until they reach proficiency see greater achievement gains than students who do not have tailored opportunities for review.[17]

The concept of focused practice is similar to mastery learning, wherein students receive and are assessed in smaller units. When students perform below proficiency on a unit, they receive additional support until they achieve mastery of the content. Research shows that mastery-learning classrooms see greater math achievement than traditional learning classrooms.[18] Classrooms that utilize distributed review and focused practice that supports subskill development and mastery see significant growth in student development of math skills.

Studies examining the impact of different instructional methods, ways to increase student motivation, and the influence of distributed and focused practice show strong effects[1], equating to small to large effect sizes of 0.28 to 1.01. As a result, programs that integrate these best practices in instruction are positioned to positively influence student math outcomes.

Assessing Students in Mathematics

[1] See Appendix for effect sizes on research-based practices.

Research indicates that in order to improve outcomes teachers need to be aware of how students are progressing toward state standards, use assessment results to modify their instruction, provide students with feedback on performance, and offer individualized math instruction and support. Additionally, when teachers incorporate technology and use dynamic content for assessment, students see positive benefits.

1. *Aligning math tests to state standards.* The creation of No Child Left Behind in 2001 led to an era of high-stakes accountability. As a result, states have become increasingly concerned with how their schools are matching up to math standards and expectations. To better understand how students are meeting state expectations throughout the year, best practices emphasize the alignment of assessments with state standards.[19,20] Periodic alignment allows teachers to find ways to change their instructional practices to meet student needs during the school year, as opposed to waiting until the end of the year to modify instruction.[21] Research shows that when math assessments align with state standards, student scores increase significantly more than when students do not receive aligned assessments.[22] When teachers use aligned data throughout the year, they gain immediate feedback on student performance toward meeting state standards and can use the data to modify their instruction.

2. *Using progress monitoring to modify math instruction.* NCTM suggests that teachers use assessment as a feedback tool to understand where their students are and need to be and then modify instruction accordingly.[23] When teachers monitor the progress of students working toward mastery and graph the results for students and themselves, students see math growth. Progress monitoring alone can be effective, but teachers observe enhanced results when they use progress feedback to tailor instruction to meet student needs.[24] For example, math teachers who receive professional development in formative assessment and talk about ways to use it more effectively see math achievement gains for their students.[25] Additionally, research shows that math teachers who receive computerized weekly progress monitoring reports along with instructional recommendations have students who make greater math achievement gains than students in classrooms where teachers have computerized progress monitoring but receive no recommendations.[26] To reap the complete benefits of progress monitoring, teachers should utilize specific feedback on student progress to adjust their instruction.

3. *Providing students with feedback on performance.* Receiving feedback on performance is one key practice for realizing math growth in students. Research shows that students who receive math feedback achieve at higher levels than students who do not receive feedback.[27] Additionally, the frequency and specificity of feedback is important as highlighted in the next two sections.

Students who receive immediate feedback demonstrate more math growth, with one study noting that math fluency doubles and accuracy triples as a result.[28,29] The effect of immediate feedback also might explain why frequent assessments are so effective. Consider that assessments on a weekly or frequent basis across a semester lead to greater math achievement growth, more positive attitudes in the classroom, and greater accuracy in self-predicting math performance.[30,31] Additionally, some research suggests that frequent classroom assessments in math are more cost effective than comprehensive school reform and class size reductions.[32]

When receiving feedback, students need information on specific tasks versus generic or personality-based feedback.[33,34] Students who receive computer- or tutor-delivered support that provides specific feedback on math performance demonstrate greater math growth over time compared to students who do not receive computer- or tutor-provided support.[35] As a result, the immediacy, frequency, and specificity of feedback influence student achievement outcomes.

4. *Offering individualized math instruction.* When modifying instruction or assessment strategies, teachers should consider individual students and then personalize instruction.[36] When students receive modified instruction based on their own math needs, they perform at higher levels compared to students who receive modified instruction specific to another student's needs.[37] Additionally, schools where students receive individualized skill practice and progress monitoring achieve at higher levels on district math assessments compared to schools where students do not receive the same type of individualized instruction and support.[38] Teachers need to incorporate additional strategies to meet the needs of all students in their classroom. In addition to whole and small group instruction, research emphasizes the importance of providing individualized and tailored feedback to improve student outcomes.

5. *Incorporating the use of technology in the classroom.* As suggested by NCTM, technology can serve as a positive aid in the math classroom.[39] Research shows that computer feedback supports math instruction and improves outcomes.[40] Specifically, when students receive math feedback or recommendations from a computer program, they score higher than students who do not receive such feedback.[41]

HOW STUDY ISLAND HELPS TEACHERS TO ASSESS MATHEMATICS PROGRESS

- Math lessons and assessments are aligned to state and Common Core standards
- Diagnostic, formative, and summative assessment results provide comprehensive information on student outcomes, and professional development resources provide suggestions for adjusting instructional practices
- Provides immediate, frequent, and specific feedback on performance
- Includes individualized mathematics instruction and support that is specifically tailored for each student's needs
- Incorporates the use of computers in the classroom, which provide task-specific feedback and support
- Includes dynamic mathematics content for review and assessment

The specific type of feedback is also important. Computer feedback that is task-specific and provides correct answers positively influences achievement outcomes.[42] Teachers also benefit from greater satisfaction with progress monitoring and a reduced amount of time on data collection and management.[43] Taken together, the integration of computers into the math classroom serves as a positive feedback, assessment, and progress monitoring tool.

6. *Providing dynamic content for review and assessment.* With the advent of new computer technologies, teachers can provide multiple opportunities to review a singular math concept through automatically generated items. These item types allow students to review concepts using many different questions that address the same content and support learning transfer to new situations.[44,45,46] Automatically generated assessment items are more secure and flexible and can result in increased student motivation for studying material.[47] Dynamic math content also leads to high convergent and discriminant validity as well as a reduced possibility of item

misinterpretation and cheating.[48,49] Finally, research finds that students who participate in math practice and assessments that are dynamic and randomly generated have greater math achievement compared to students who receive traditional practice on paper.[50]

Research on best practices in progress monitoring including standards alignment, modifying instruction, providing feedback and individualized support, incorporating technology and using dynamic content is strong, with effect sizes ranging from 0.29 to 0.95. As a result, programs that incorporate these best practices in progress monitoring can have positive small to large effects on math skill development.

Study Island as a Tool for Developing Student Math Skills

Through different instructional strategies and methods to monitor student progress, Study Island includes research-based practices linked to the development of student math skills.

Study Island provides K-12 online learning modules in math instruction that program developers have aligned with state-specific and common core standards.

The program exposes students to math content through online lessons that integrate the use of pictures, videos, animations, and text to support student comprehension. *Study Island* fosters motivation by focusing on assessment and student mastery of content and including symbolic rewards for progress (i.e., students receive a blue ribbon when they master a concept).

Teachers can specify the amount and frequency of math practice, resulting in the opportunity to distribute practice across multiple days or weeks. Additionally, the program allows for focused practice by breaking concepts down for students when they need additional help or support. Once students master lower level concepts, *Study Island* cycles the students back up to higher math content levels.

Study Island aligns math content with state and Common Core standards, allowing teachers and administrators to remain apprised on student performance toward state expectations. Additionally, a variety of formative, summative, diagnostic test results, and professional development resources offer data and resources for modifying instruction. Students receive immediate, frequent and task-specific feedback on their math performance through *Study Island*. The program provides review and assessment at a level that is individualized for each student, allowing for personalized math learning and review.

Through use of an online learning platform, *Study Island* helps teachers to integrate progress monitoring into their normal instruction and provides computerized math feedback. The computer platform uses dynamic and automatically generated content for math items. As a result, students have multiple opportunities to practice a specific concept without reworking the same problem repeatedly.

Study Island, when integrated into normal classroom math instruction, can positively influence math achievement through use of research-based practices in instruction and assessment.

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Appendix. Effect Sizes of Research-Based Practices

Effect sizes provide information on the relative strength of a set of findings. Effect sizes explain the standardized deviation in difference between two groups. In other words, an effect size of 1.00 means that an average person in the treatment group scored 1 standard deviation, or 32 percentile points, higher than the average person in the control group. The following table includes information on the effect sizes of referenced studies when effect sizes were available or able to be calculated.

Table 1. Effect sizes for research-based practices in developing math skills

Component	Range of effect sizes	Components addressed
Instructional Strategies	0.28 to 1.01	• Using different methods of instructional delivery[51,52,53] • Math motivation in the classroom[54,55,56] • Providing distributed and focused math practice[57,58,59]
Progress Monitoring	0.29 to 0.95	• Aligning math assessments with state standards[60] • Using assessments to modify instruction[61,62,63] • Providing students with feedback[64,65,66,67,68] • Providing individualized instruction and support[69,70] • Using computers to monitor progress[71,72,73] • Providing dynamic content for review and assessment[74]

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