i-Ready

Research Base for *i-Ready Personalized Instruction* for Mathematics

Executive Summary

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Research on mathematics instruction provides a solid foundation of practices that help students gain proficiency in the subject. Curriculum for K–8 that supports teachers in translating research and expert recommendations into practice can make significant headway in improving mathematics proficiency for all students.

Standards-based instruction. Recommendations from the National Council of Teachers of Mathematics (NCTM) and the Common Core State Standards (CCSS) Initiative include the following:

- Curriculum content in the elementary grades should address number and operations, algebraic thinking, measurement, data analysis, and geometry.
- Instruction should promote sense making and understanding of mathematical concepts and procedures in the context of meaningful problem solving.
- Sense making requires encouragement of and guidance on reasoning about relationships among mathematics concepts and procedures and on recognizing patterns and structure within problem situations so students come to see mathematics as a system of interrelated ideas.
- Instruction should support student interpretation and development of simplified models of real-life problems, represented in multiple ways—graphically, symbolically, and verbally.
- Instructional activities should encourage meaningful communication with others about mathematical arguments, evidence, and conclusions.
- Instructional activities should encourage and provide support for perseverance and productive struggle when attempting to solve challenging mathematics problems (CCSS Writing Team, 2011–2018; CCSS Initiative, 2019; NCTM, 2000, 2014; NGACBP & CCSSO, 2010; NRC, 2001).

Meaning making in mathematics. Research-based recommendations about making meaning in mathematics include the following:

- Instructional activities should be planned and sequenced so students can extract mathematical concepts early on from concrete and action-based experience. Then, as students develop basic concepts, instructional activities should involve exploration of how these basic concepts are related (Sfard, 2003).
- Mathematics should be taught in the context of problem-solving activities (Burns, 2015; Lesh & Zawojewski, 2007; Hiebert, 2003; NCTM, 2000; Sfard, 2003).
- Students should be active participants in mathematics learning who engage in instructional activities that involve examining, representing, transforming, solving, applying, proving, and communicating about mathematical concepts and procedures (Hiebert, 2003; NRC, 1989).

Developing conceptual, factual, and procedural knowledge. Research-based recommendations about the relationships among conceptual, factual, and procedural knowledge include the following:

- Educators should take into account children's informal entry knowledge and build on it, while also considering individual differences (Baroody & Ginsburg, 1986; Hiebert, 2003).
- Instructional activities should feature mathematics problems that call for students to invent solutions based on their prior knowledge and understanding, while also providing practice of mathematics skills they have previously learned (Hiebert, 2003; Sfard, 2003).
- Students should be guided to understand the thinking behind mathematics procedures before over-practicing them (Baroody & Ginsburg, 1986; Hiebert, 2003).

Problem solving, modeling, and representation. Research-based recommendations about incorporating problem solving in mathematics education include the following:

- Problem solving should provide a context for developing both conceptual understanding and procedural knowledge (Sfard, 2003).
- Instructional activities should often involve students in solving problems that require them to both think inventively and practice the skills they have already learned. The problems should require students to draw upon the system of mathematical ideas they already understand well (Hiebert, 2003; Sfard, 2003).
- Problem-solving activities should strike a balance in terms of the level of challenge—offering enough challenge to stimulate further development of conceptual understanding, but not so much challenge as to cause frustration. In this regard, instruction should take into account individual differences among students (Sfard, 2003).
- Problem-solving activities should include representation of problems in mathematical models, such as diagrams, graphs, and equations (Lesh & Zawojewski, 2007; NCTM, 2000, 2014). Over time, problem solving should help students develop representational fluency among different representational forms (Lesh & Zawojewski, 2007).
- Mathematics instruction should encourage analysis of multiple methods of solving problems and comparison of methods (Hiebert, 2003).
- Educators should encourage students to provide explanations of their method(s) of solving mathematics problems (Burns, 2015; Hiebert, 2003).

Growth mindset. Research suggests that instruction should encourage persistence of effort rather than reinforcing the idea that intelligence and ability are fixed. Teachers and instructional tools should focus student praise on the steps students are taking to master learning material rather than on their innate intelligence (Blackwell, Trzesniewski, & Dweck, 2007; Dweck, 2015).

How *i-Ready* aligns with the research. *i-Ready Personalized Instruction* for Mathematics addresses all of the critical domains specified in the NCTM and CCSS—Number and Operations, Algebra and Algebraic Thinking, Measurement and Data, and Geometry—and follows key recommendations from these initiatives, research, and expert opinions.

- *i-Ready Personalized Instruction* for Mathematics lessons are designed to help students construct meaning around mathematics concepts and principles, basic mathematics facts, and procedures—and the structural relationships among these.
- The adaptive *i-Ready Diagnostic* assessment places each student in a personalized learning path through online lessons. This helps ensure that the lessons build on each student's prior knowledge and that each student is working at an appropriate level of challenge.
- Lessons are designed around problem-solving challenges that call for a combination of invention and practice of previously learned procedures. Students are encouraged to try out multiple strategies to solve a problem. The mathematics problems are significant in the sense that they require students to use their prior knowledge about the system of mathematical concepts. Problem scenarios are designed to be meaningful and relevant to students as well as culturally and linguistically responsive.
- *i-Ready Personalized Instruction* for Mathematics problem-solving activities involve representation of problems in mathematical models. Instruction lessons present students with tools to use in modeling the problem at hand. If students struggle in their use of representational tools, the system provides scaffolded support.
- *i-Ready Personalized Instruction* for Mathematics lessons balance opportunities for problem solving with practice of previously learned skills. Lessons include a mix of open and guided explorations of challenging problems to solve, plus independent practice of previously learned concepts and procedures.
- *i-Ready* provides teachers with lesson plans in the Tools for Instruction—to be used independently of the online lessons—that encourage whole class or small group conversation about students' various strategies for solving mathematics problems.
- *i-Ready* encourages students to persist in their efforts to understand mathematics concepts and solve problems. When students don't succeed with a challenging problem, scaffolded feedback suggests strategies for successfully solving the problem and encourages them to try again. Progress monitoring screens for younger students (Grades K–2) praise them for their efforts and perseverance, and the student dashboard provides students across the K–8 grade span with a record of their effort over time.

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