Aha!Math™

Research Summary

The Research-Based Instructional Model for Aha!Math

Note: research citations are at the end of this document.

Learning.com has from its founding in 1999 built its solutions with a specific pedagogical approach: an instructional model explicitly designed to maximize student learning. This instructional model incorporates the most current research into how students learn, and how curricula that leverage Internet-based technology creates the most effective learning experiences. Learning.com's goal with this design is to provide effective online supplemental curricula that maximize student learning. Aha!Math is built on this instructional model.

Research shows that Web-based learning stimulates student learning not only because it activates the brain, but also because it allows for genuine interaction, fluidity, and immediate feedback. We know from the research that these qualities enhance learning. Research also shows that the use of narrative and story increases student engagement, keeping students involved in the learning process, especially if the material is presented in well thought out and thematic contexts.

The Learning.com interactive instructional model incorporates the following critical characteristics that have been identified by research to enhance learning:

- Multisensory experiences – visual, auditory, and interactive – to allow for richer, more complete learning.
- Opportunities for students to model, and thus hone their new skills.
- Digital coaches that support students with multiple levels of immediate feedback and instructional support.
- Content designed to be relevant to students' lives, humor, and a sense of playfulness, that in combination lead to motivated and engaged learners.
- Context for learning experiences, giving students a clear understanding of how and when they would apply their knowledge and skills to solve problems.
- Game-based learning, all within real-world contexts that students find relevant and interesting, and that include opportunities for students to apply specific learning strategies and build their problem-solving skills.

Incorporating NCTM Focal Points

The National Council of Teachers of Mathematics has identified curriculum focal points for pre-kindergarten through Grade 8 mathematics. To build students' strength in the use of mathematical processes, instruction in content areas should incorporate these focal points, which Aha!Math incorporates throughout its content, including

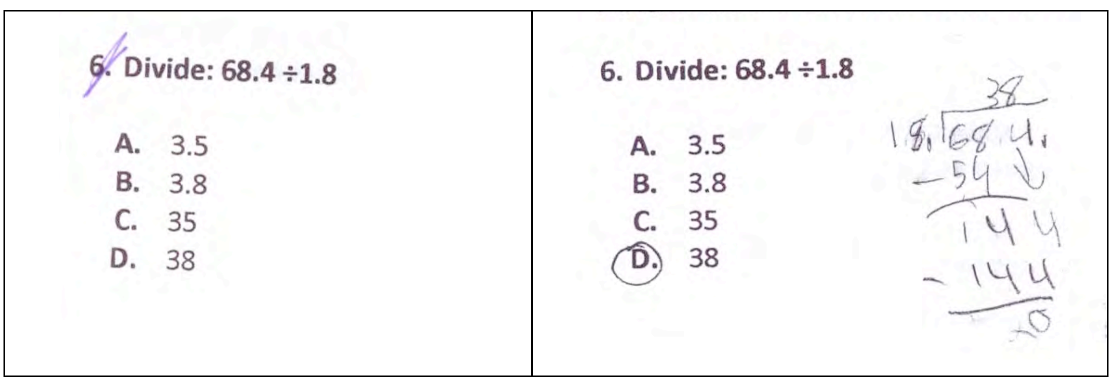
- the use of mathematics to solve problems,
- an application of logical reasoning to justify procedures and solutions, and

- an involvement in the design and analysis of multiple representations to learn, make connections among, and communicate about the ideas within and outside of mathematics.

Small-scale Study Using Aha!Math

In a recent short-term intervention program using Aha!Math with low achieving students it was found that for those students who completed the program there was a significant increase in achievement. In the spring of 2008, a group of third- to sixth-grade students identified by their teachers as far below proficiency in math at Alicia Cortez Elementary School in Chino, California participated in an eight-day intercession program. Each lesson was 35 minutes. For those third-grade students who completed the Aha!Math course there was a significant statistical achievement gain – a 24 percent increase in the average score from pretest to posttest on the skills addressed in the intercession. Students who completed the program in the other classes also showed achievement gains.

When these same students took the California STAR state test, 26.7 percent of the third grade students moved their testing proficiency up at least one proficiency level, while fully half of the fourth grade students moved up one proficiency level. For both grades, student work changed on the assessment items as well: they attempted more problems, showed additional work and attempted problems using new approaches.



In the example, above, a student attempted a problem on the post-test (right) that they skipped on the pre-test (left).

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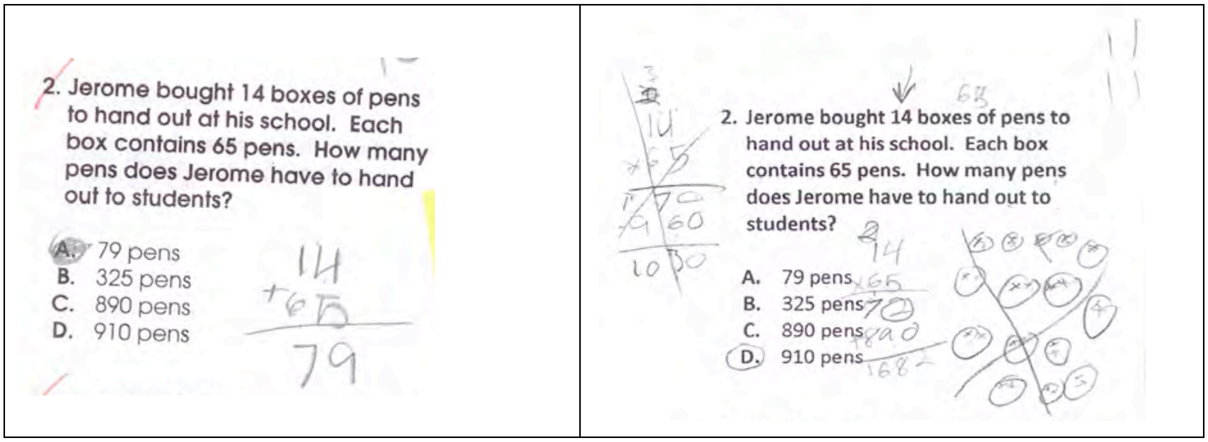
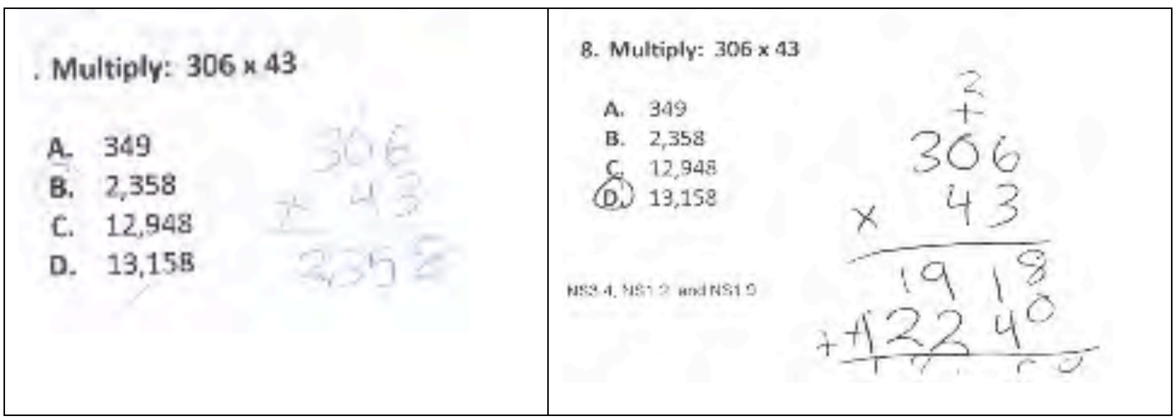


In this example, a student uses a new approach to solve a problem.



And in the final example, a student moves from an incorrect algorithm on the pretest (left) to a corrected algorithm on the posttest (right).

Those students in fourth, fifth and sixth grades who participated in the intercession did not complete all the assigned curriculum from Aha!Math, and therefore were not included in the statistical analysis of this study. However, fifth-grade students in the lower two quartiles on the study's pretest made growth on the post-test, and students in the intercession moved their California STAR testing proficiency level up at least one level. While students in sixth-grade didn't complete all the lessons for all the standards tested, for those standards completed these students showed growth.

The results of this small-scale study demonstrate that Aha!Math did make a difference in student mathematical knowledge on the specific covered standard. It is important to note that while students in grades four through six did not complete all the assigned Aha!Math instruction, by examining the means scores by standard for the content that students actually completed, every mean score increased on the corresponding standard posttest. This suggests that for the content that students cover through Aha!Math, their mathematical achievement will increase. A larger, structured efficacy study using test and control groups is currently underway.

Aha!Math Quizzes as Instruction – The Research Basis

Aha!Math quizzes are designed as more than evaluative instruments to provide insight to teachers. They also provide *instructional* value for the student. Aha!Math quizzes give students practice at retrieving information, to enhance student recall, and ultimately to improve student performance on tests, including high-stakes assessments. There is a strong research basis for using quizzes as an instructional device, as noted below.

Several studies have shown quizzes together with immediate correct answer feedback, as implemented in Aha!Math, is more effective than merely reviewing or rereading content. In the absence of corrective feedback, any errors produced on one test will remain present, and will reappear on subsequent tests.

Researchers have found that having students take a test is almost always a more potent learning device than having students spend additional time studying the target material. And several recent studies have shown that testing not only enhances learning – it also reduces the rate at which information is forgotten.

Teachers should give quizzes at spaced intervals to re-expose students to key content and to give them practice in retrieving information. Recent research has confirmed earlier studies showing that being quizzed or tested on studied material improves student performance on final tests.

How Aha!Math Addresses Bloom's Taxonomy

Bloom's Taxonomy provides six level for classifying educational goals and objectives and is often used to evaluate assessment items to ensure that students are being assessed on more than simple recall.

Aha!Math addresses the higher levels of Bloom's Taxonomy in several ways. The Instruction Modules, with their emphasis on understanding the "why" as well as the "how" of mathematics, model analysis and synthesis by showing how these higher-level thinking skills are used to create new knowledge and techniques from existing ones. For example, in the fourth grade Instruction Module, "The Distributive Property," students are introduced to the procedure of multiplying two-digit numbers by analyzing patterns in the multiplication table, continuing those patterns, and ultimately synthesizing a rule for multiplication from what they have found. Evaluation is also a critical, if generally implicit, component of the Instruction Modules; it is most apparent in those that have to do with estimation, in which students determine the reasonableness of estimates based on previous knowledge.

Games, which develop problem-solving as well as mathematical skills, and Activities, which allow students to explore the basis for procedures in greater depth, also encourage the student to use higher-level thinking. For example, the "River Crossing" game (third grade) has the goal of getting the digital coach across a river by defining the most effective multiplication sentences that will help them achieve that goal. Students are given multiple possibilities each turn, must develop a strategy (synthesis) and determine which possibility best allows them to carry out that strategy (analysis). Similarly, in "Create a City," a fourth-grade game, students must build a rectangle according to given directions; this requires evaluation to determine whether the finished product meets the specifications. In the "Sunny Side Up" game, students demonstrate that a common value can be represented by different numbers and spatial arrangements (analysis).

Aha!Math and Special Needs Students

Aha!Math's use of digital coaches is important for special needs students. In classroom settings the emotional expressions of other participants (teacher and peers) significantly influence a student's affective and cognitive characteristics, e.g., the student's emotions, self-conception, and motivation. In the same way that students are affected by the emotional state of their teachers and peers, they are affected by the emotional states of digital coaches, which ultimately influences their emotions in learning within a computing environment. The use of a digital coach can make students feel more comfortable and more at ease with the learning tasks and the learning environment. Van Mulken et al. (1998) propose that 'the presence of Persona may […] take away the fear of failure that some students experience with regard to particular educational material' (p. 63). This is especially valuable for an academically challenged student.

Aha!Math is specifically designed with a consistency in content and emotion that has a significant impact on learning by special needs students. Students who are struggling academically – either because of a learning disability or because the curriculum in use has not been effective for their learning style – may need to hear instruction on a concept multiple times. When that repeated instruction isn't the same – even in minor ways – it can increase student confusion instead of spurring understanding. Additionally, these students are highly sensitive to the emotional content in an instructor's voice. Whether it's frustration that creeps into the edges of a teacher's voice as a student still doesn't understand or the relief they hear when they finally get an answer right, that emotional content can create high anxiety levels and seriously distract the student from learning.

The digital coaches in Aha!Math give the student emotionally consistent instruction and feedback, whether it's repeating instruction again and again, correcting student responses, or rewarding a correct answer. Aha!Math also gives the student the opportunity to revisit the instructional content and to hear the instruction again with no variations in presentation, decreasing the likelihood of confusion that can come from the differences that we unintentionally introduce when as educators we revisit a concept. Students can repeat the instruction as many times as they want without wearing the patience of their instructor. This consistency in content and emotion has high value for special needs students.

Aha!Math and RTI

Response to Intervention (RTI) has three tiers: the classroom (tier 1), small group (tier 2), or individual (tier 2 and tier 3) intervention. RTI at its most basic is a structured method for providing intervention. The instructional design for Aha!Math provides teachers with multiple options for delivering instruction in each of these tiers. The variables here are the implementation environment, the number of students, the teacher-to-student ratio, and the student needs. Aha!Math can be used in all tiers.

For example, in tier 1, an Aha!Math Instruction Module (IM) may be used with the whole class to introduce a concept, with the teacher pausing the online delivery of instruction to explore student understanding and initiate discussion about the concept.. In tier 2, Aha!Math can be used with a small group with the teacher focusing on specific parts of the instruction and engaging the students in discussions about the math. Teachers may also combine the use of manipulatives with the online instruction, having students model the math concept being taught in Aha!Math with manipulatives and following that up with discussions about how what they're doing is different (e.g., different objects to model the number sentence) and the same (e.g., same numbers, same operations). In tier 3 instruction, teachers may work with a student at a computer and use the online instruction to maintain an instructional focus, pausing and asking questions, asking the student to explain what he just heard, or use scratch paper to write out the math problems to solve them, or use manipulatives to model the problems or create new ones. These discussions provide teachers with insight into student understanding and assist them in differentiating instruction for that student. Games, Lessons and Quizzes also are effective at all tiers, and can be used for group or individual learning. Activities may be useful on a select basis in tier 3 but are certainly of use in tier 1 and 2.

Aha!Math is an excellent component of a good RTI program with curriculum that addresses the specific learning goals at each tier.

Frequently Asked Questions and the Research-Based Answers

Note, the full research citations are in the end of this document.

Q: Are the narrative contexts for the games merely a fun element for students? Does it make an instructional difference whether there's an underlying theme?

> **A:** Thematic instruction has been shown to increase student achievement. (Beane, 1997; Kovalik, 1994).

Q: Why is Aha!Math designed to require students to continue working on lessons until they get at least three of the interactive elements correct?

> **A:** Asking students to continue working on a task until it is completed and accurate (until the standard is met) enhances student achievement. (Marzano, Pickering, & Pollock, 2001).

Q: In the instructional content – K-2 Games and 3-5 Lessons – in which students can get things right or wrong, why do the digital coaches say more than just "that's right" or "that's wrong"? Should they really be reviewing the content the student needs to know?

> **A:** Yes. When feedback is corrective in nature – that is, it explains where and why students have made errors – significant increases in student learning occur. (Lysakowski & Walberg, 1981, 1982; Walberg, 1999; Tennenbaum & Goldring, 1989).

Q: Why do digital coaches give feedback for every right answer in addition to every wrong answer immediately after the student finishes answering?

> **A:** Effective feedback is timely feedback. Delay in providing students' feedback diminishes its value for learning. (Banger-Drowns, Kulik, Kulik, & Morgan, 1991).

Q: Is there real value in providing different models and using graphic representations of math concepts to simulate problem solving?

A: Yes. Students learn more when they are presented information in several modes (Paivio, 1986).

Q: Is it better educationally to simply focus on the formula or number sentence and not distract students with graphics and different models?

A: No. Simulation environments and modeling have unique capabilities for enhancing learning. (Gordin & Pea, 1995).

Q: Learning games have been described by some as "edu-tainment." Are games valid instructional tools?

A: Yes. Aha!Math games are focused on specific learning objectives that are listed for each item in the teacher's view curriculum section. The beneficial effects of gaming are most likely to be found when specific content is targeted and objectives precisely defined. (Randel et al 1992).

Q: Does the "fun" nature of games undermine the instruction?

A: No. Gaming teaches competition strategies, cooperation and teamwork, and conflict resolution. (Neubecker, 2003).

Q: How does Aha!Math offer better learning to students than other supplemental programs?.

A: Most technology-based supplemental math programs simply ask students to recall what they've learned. They often focus solely on *computational* abilities and recall, and not *conceptual understanding*. They do not develop students' mathematical reasoning. Aha!Math does. Higher-level questions that ask students to analyze information result in more learning than simply asking students to recall information. (Redfield & Rousseau, 1981).

Research Citations for Learning.com's Instructional Design

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Additional Research

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