



SpiralMath

Using the power of formative assessment to help students master
mathematics.

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www.spiralmath.net

joseph.mills@spiralmath.net

robin.mudge@spiralmath.net

david.robson@spiralmath.net

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EXECUTIVE SUMMARY

SpiralMath is an automated learning tool that helps students master mathematics. Using brief daily quizzes taken on computers or tablets, SpiralMath uses repetition to interleave older concepts with current material. This process helps students retain concepts and results in better test performance.

Data that is generated by the SpiralMath system provides valuable insight to students and teachers. Students can view their scores instantly following a quiz and teachers can view compiled data in multiple formats to determine where more attention is needed for each student, for each standard, and for each class.

In this white paper, you will learn how SpiralMath performs these tasks while requiring no additional work from teachers.

THE CHALLENGE: IMPROVING STUDENT PERFORMANCE ON STANDARDIZED MATH TESTS

Teachers working to help students master mathematics face multiple challenges. To ensure that students are achieving the best results possible, teachers need to do two things effectively:

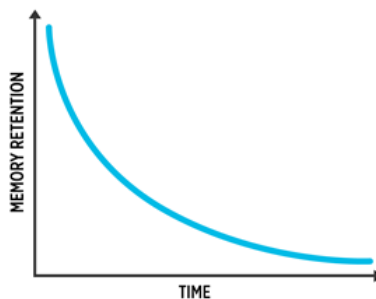
1. Prevent students from forgetting skills over time as new topics are introduced.
2. Manage large amounts of data to enable quicker, targeted responses where and when remediation is needed.

Without a tool in place for managing each of these processes, students and teachers will always struggle to perform at their highest levels.

The Problem of Forgetting

Math teachers work hard to help students learn and *retain* concepts. However, even the best-performing students struggle to retain information as weeks pass and new concepts are introduced.

If the things we learn are not reinforced periodically, a lot of knowledge is lost over time. Hermann Ebbinghaus, a pioneer in the study of human memory, conducted experiments that revealed how quickly knowledge is lost. He illustrated the phenomenon using a graph called the Forgetting Curve, where learned information is retained initially near the top of the vertical axis. Over time, moving from left to right along the horizontal axis, the ability to recall the information drops off steeply as time passes:



The problem of forgetting can be especially acute for math students who are expected to learn some 40 skills in a single year. To perform well on standardized tests, students must find a way to keep learned skills near the top of the Forgetting Curve as the school year progresses and new concepts are added.

Overwhelming Data Management Requirements

Teachers today are responsible for tracking large amounts of performance data related to standardized tests. The Common Core State Standards can require as many as 40 skills per year. If a 5th Grade math teacher, teaching 5 classes, wishes to check students' performance weekly, he must manage 180,000 data points by the end of the year, as shown below:

$$25 \text{ students} \times 5 \text{ classes} \times 40 \text{ standards} \times 36 \text{ weeks} = 180,000 \text{ data points}$$

Managing 180,000 data points can be daunting, if not impossible. Contrast today's data requirement with the 500 data points that a 5th Grade math teacher managed in the past:

$$25 \text{ students} \times 5 \text{ classes} \times 4 \text{ report cards} = 500 \text{ data points}$$

Without a tool for managing such a heavy load, teachers could get lost in sea of data. And time spent managing data is time NOT spent teaching students.

In the next section, we discuss how SpiralMath can help overcome both the forgetting curve and the massive data management requirement placed on teachers.

FORMATIVE ASSESSMENT: A POWERFUL TOOL FOR STUDENTS AND TEACHERS

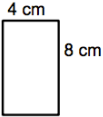
Standardized tests are *summative* in nature, intended to evaluate a student’s knowledge at a point in time. Students take a number of summative-type tests during a school year, including midterms and finals. While invaluable for gauging achievement, summative assessment provides feedback only AFTER the time available for improvement has passed.

Formative assessment, however, is forward-looking and can be used to identify and “course correct” topics where a student is performing poorly. When used consistently throughout a school year, formative assessment allows for positive actions to be taken PRIOR TO a high stakes summative assessment.

SpiralMath uses formative assessment to help students retain concepts by revisiting those concepts at prescribed intervals. The quizzes keep skills fresh and provide insight into whether content has truly been mastered. Teachers can use the resulting data to target problem areas for individual students, groups of students, or whole classes.

WHAT IS SPIRALMATH?

Each day, at the beginning of math class, students use a tablet or computer to take a five-question quiz. This task typically takes three to five minutes and can be performed while roll is being taken. Each question is keyed to a specific math standard (in red below). The quiz is scored instantly by a remote server which stores and reports each student's performance.

| Grade 5 | | Quiz 0319 | Standard | | | | | | | | | | | | |
|---|--|--|-----------|----------|----------|----|----|----|---|----|---|----|--|--|----------|
| 1 | <table><tr><td>INPUT</td><td>OUTPUT</td></tr><tr><td><i>r</i></td><td><i>s</i></td></tr><tr><td>44</td><td>11</td></tr><tr><td>36</td><td>9</td></tr><tr><td>32</td><td>8</td></tr><tr><td>28</td><td></td></tr></table> | INPUT | OUTPUT | <i>r</i> | <i>s</i> | 44 | 11 | 36 | 9 | 32 | 8 | 28 | | | 5.OA.B.3 |
| INPUT | OUTPUT | | | | | | | | | | | | | | |
| <i>r</i> | <i>s</i> | | | | | | | | | | | | | | |
| 44 | 11 | | | | | | | | | | | | | | |
| 36 | 9 | | | | | | | | | | | | | | |
| 32 | 8 | | | | | | | | | | | | | | |
| 28 | | | | | | | | | | | | | | | |
| What is the rule for the function table? A. subtract 33 B. divide by 3 C. multiply by 4 D. divide by 4 | | | | | | | | | | | | | | | |
| 2 | What is the perimeter of this figure? Enter the answer. _____ (24 cm) |  | 4.MD.A.3 | | | | | | | | | | | | |
| 3 | Enter the answer _____ (70414) | $\begin{array}{r} 4,142 \\ \times 17 \\ \hline \end{array}$ | 5.NBT.A.5 | | | | | | | | | | | | |
| 4 | The product of three whole numbers is 60. The sum of the same three numbers is 12. What are the numbers? A. 2, 5, 6 B. 2, 3, 10 C. 3, 4, 5 D. 1, 2, 30 | | 4.OA.A.3 | | | | | | | | | | | | |
| 5 | Bob worked 37 hours the first week and he worked 25 hours the second week, how many hours did he work in two weeks? A. 12 B. 52 C. 62 D. 124 | | 4.MD.A.2 | | | | | | | | | | | | |

NOTE: Standard references (in red) are not visible in actual student quizzes.

For each grade level, the server contains 180 quizzes, one for every school day. As the school year progresses, questions about a specific standard begin to appear in the daily quiz once that standard is reached in the curriculum.

Repetition, or “spiraling back”

Once a student is quizzed on one of the standards, he or she is questioned again a few days later on that same standard, then again a couple of weeks later, continuing through the end of the school year. In this way, the system automatically SPIRALS back through the curriculum. The spaced repetition of standards improves student retention all year and into the following year.

Data. Lots of valuable data.

SpiralMath scores quizzes in real time and provides instant feedback on each student, class, and standard. SpiralMath also retains and compiles data from all of the quizzes – data that can be viewed in multiple, user-friendly ways that are discussed later in this white paper.

STUDENT AND TEACHER BENEFITS

SpiralMath helps both students and teachers achieve their goals in the classroom. Also, the benefits of SpiralMath are compounded over time as students are able to help themselves and teachers can better understand where to focus their time and expertise.

Student Benefits

- SpiralMath provides instant feedback on every math concept throughout the year. This process lets students “see” when a concept is not fully mastered or is sliding down the forgetting curve.
- Students are empowered to identify their own specific areas to reach or reestablish mastery of a concept. Once a problem area is identified, students can revisit that concept without spending valuable time on topics that are already mastered.

Teacher Benefits

- Because students are continually aware of the areas where they need the most help, teachers spend less time identifying those areas and more time addressing them. Data that is generated and organized by SpiralMath provides a powerful vehicle for making strategic teaching adjustments.
- Formative assessment is a powerful learning tool but it is seldom used in the classroom because it requires that a teacher:
 - create a quiz
 - administer the quiz
 - collect and score the answers
 - compile and analyze the data

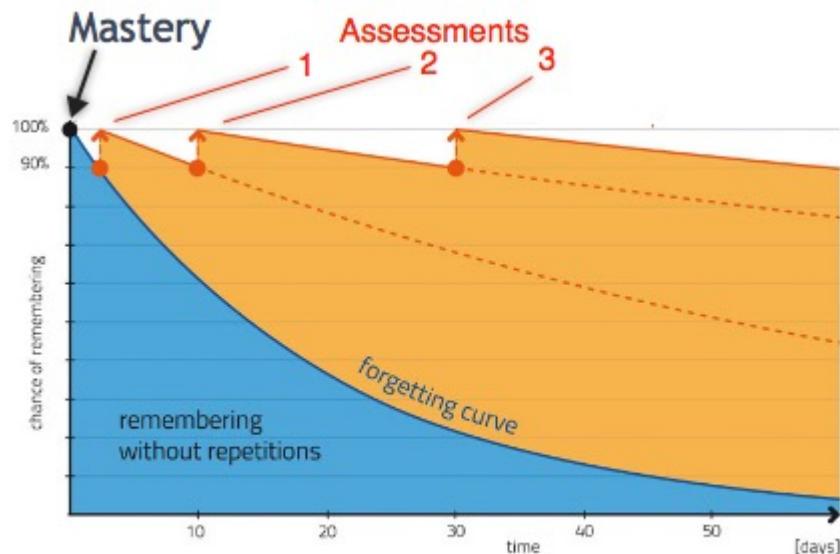
These tasks add far too much time to a teacher’s already-heavy workload. Because SpiralMath performs these tasks automatically, the benefits are gained with **NO ADDITIONAL WORK REQUIRED**.

WHY DOES SPIRALMATH WORK?

Studies show that periodically quizzing students on concepts helps them retain those concepts longer – even better than re-studying. SpiralMath continually reintroduces concepts through quiz questions during the school year. Information that might be sliding down the forgetting curve gets bumped back up when it is included in one of the daily quizzes.

SpiralMath is not the first learning tool to use spaced repetition to improve memory. In 1985, Piotr Woźniak created a software program called SuperMemo that uses an algorithm to refresh concepts for learners at increasing intervals of time on topics of their choice. SuperMemo is still available today and continues to help people overcome the forgetting curve and learn voluminous subjects such as languages.

The theory behind SuperMemo and SpiralMath is illustrated in the following graph. Each time a student is quizzed on a concept, mastery of that concept is reestablished and the forgetting curve is “reset” at 100%. Notice, however, that each successive forgetting curve becomes shallower, meaning information is retained much longer over time following each repetition.



SpiralMath also helps students by *interleaving* concepts. Students become accustomed to seeing older concepts and current material together, mimicking the test format, and this improves their performance on the exam.

POWERFUL, USER-FRIENDLY DATA VIEWS

SpiralMath compiles the daily quiz results into a database that can be accessed and analyzed in multiple views. Students can access three data views and teachers can access six data views.

Using the data views, students can quickly identify their problem areas and teachers can determine which students need help with specific skills and which topics should be taught again using a different approach.

In this view, a student can instantly see his or her results on today's quiz. The *Quiz Number* pull-down menu allows students to select and view any previously-taken quizzes.

| | | | | | |
|--------------------|---------------------------|--------------------------|-------------------------|--------------------------|--------------------------|
| Colgate Elementary | Period 3 | Grade 5 | | | |
| Sam Phelps | Teacher: | Mr Benson | | | |
| Quiz Number | 022 ▼ | Report Date: 5 Nov 17 | | | |
| CCSS | 5.NBT.A.1 | 5.OA.B.3 | 5.NFA.2 | 5.MD.C.3 | 5.OA.A.2 |
| Question Number | 1 | 2 | 3 | 4 | 5 |
| Answers | 105 | 1000 | 120 | 7 miles | C |
| Red = Incorrect | | | | | |

Sam missed questions 2 and 5 on today's quiz.

1.
$$\begin{array}{r} 15 \\ \times 7 \\ \hline 105 \end{array}$$

2.
$$\begin{array}{r} 10 \\ \times 10 \\ \hline 100 \end{array}$$

3.
$$\begin{array}{r} 15 \\ \times 8 \\ \hline 120 \end{array}$$

He can see the correct answers here

4. April and Bill were preparing to run in a 10K race. They ran every day after school. Bill ran 2 miles every day. April ran 3 miles every day. In seven days, how many more miles did April run than Bill?

- A. 5 miles
- B. 7 miles
- C. 15 miles
- D. 35 miles

5. A fourth grade class was going on a field trip. There were 28 students and 4 chaperones going on the trip. Two student and two chaperones were sick that day. There were 4 vans to take the students and chaperones on the trip. If the same number of passengers went in each van, how many were in each van?

- A. 7
- B. 8
- C. 24
- D. 32

In this view, a student can see his or her degree of mastery on all skills (CCSS standards) studied so far.

Colgate Elementary





















Mr Benson
Period 3

Grade 5

Marcia Bronowski

Date of report

11/5/2016

| CCSS | Description | Last four questions |
|-----------------------------|--|---|
| 5.OA.A.1 | Evaluate expressions containing parentheses, brackets, or braces. |  |
| 5.OA.A.2 | Write expressions that record calculations, and interpret expressions. |  |
| 5.OA.B.3 | Generate two numerical patterns using two given rules. Form and graph ordered pairs. |  |
| 5.NBT.A.1 | Shifting one position mean 1/10 or 10X. |  |
| 5.NBT.A.3.B | Compare two decimal numbers to 0.001 |  |
| 5.NBT.A.4 | Round decimal numbers. |  |
| 5.NBT.B.5 | Multiply multi-digit whole numbers. |  |
| 5.NBT.B.6 | Divide multi-digit whole numbers. |  |
| 5.NBT.B.7 | Calculate with decimal numbers and explain. |  |
| 5.NF.A.1 | Calculate fractions with unlike denominators |  |
| 5.NF.A.2 | Word problems involving addition and subtraction of fractions. |  |
| 5.NF.B.3 | Interpret fractions as division and solve word problems. |  |
| 5.NF.B.4 | Extend multiplication to multiply a fraction by a whole number or a fraction. |  |
| 5.MD.A.1 | Solve problems that require converting metric units. |  |
| 5.MD.B.2 | Understand and apply the concept of volume. |  |
| 5.OA.A.1 | Evaluate expressions containing parentheses, brackets, or braces. |  |
| 5.NBT.A.3.B | Compare two decimal numbers to 0.001 |  |
| 5.NBT.A.4 | Round decimal numbers. |  |
| 5.NBT.B.5 | Multiply multi-digit whole numbers. |  |
| 5.NBT.B.6 | Divide multi-digit whole numbers. |  |

ABOUT SPIRALMATH

SpiralMath is derived from an earlier learning tool, the Differentiated Mathematics Program. Created by Joe Mills, Differentiated Mathematics was used in dozens of U.S. school systems and resulted in dramatic increases in student math performance. The program was especially effective at low-performing schools.

The founders of SpiralMath come from a diverse range of educational backgrounds:

Joseph Mills, Jr — Mathematics Teacher and Learning Expert

Joe is supervising the mathematics content of SpiralMath.

- Taught or supervised teachers in all grades K-12.
- Worked with University of Delaware creating the Delaware state math curriculum.
- Served as Mathematics Supervisor for the state of Delaware.
- Managed math curriculum projects in 10 states focusing on standards, instruction, and assessment, especially using data to inform instruction.

David Robson — Science Teacher, Magazine Editor, and Software Developer

- Experienced science teacher (high school chemistry, physics, computer science).
- Founding Editor of *Chem Matters* magazine, which David grew to a paid circulation of 52,000 in six nations.
- Developed the online system edPlans.com which hosts curriculum and lesson plans for schools and teachers and which has been adopted by the Core Knowledge Foundation.

Robin Mudge — Instructional Systems Strategist, Educational Television Producer, and Expert in Consumer-Facing Educational Systems

- Produced and directed science documentary programs for over 20 years at the BBC.
- Supported the BBC Computer literacy project — produced films and TV programs teaching young people to program one of the earliest personal computers (the BBC Micro).
- Served as chief architect for the BBC Learning Station, an interactive learning service for children, parents, and teachers.
- Was invited to the US to consult for the Corporation for Public Broadcasting, developing e-learning for K-12 students.

Alfred Werner — Learning Expert (mathematics, foreign languages), Web Developer, and Database Administrator

- Skilled full-stack web developer, expert in PHP, Python, JavaScript, CSS, and many frameworks.
- Developed a web-based sandbox and showcase system for the education program ThinkQuest, which supplied STEM activities and contests for students.
- Developed the information architecture and conducted training sessions to launch the Sloan Careers In Science program, which led to a repository of information about 150 scientific and technical careers.