

WHITE PAPER

How digital tools prepare students for the 21st century

A CollinsConsults White Paper Prepared for
Inspiration Software, Inc.

The United States currently ranks seventeenth in the world on tests assessing science and math knowledge and skills.

The United States is falling behind

U.S. students are falling behind in math, science, and information management skills as reflected by results from international assessments such as PISA (Programme for International Student Assessment) and TIMSS (Trends in International Mathematics and Science Study). Both show that U.S. students are not properly prepared for the 21st century. The United States ranks seventeenth in the world on tests assessing science and math knowledge and skills, and almost one-third of all K-5 teachers report teaching science two or fewer days per week (Bayer, 2008). The U.S. Department of Education, National Center for Education Statistics, ranks the United States 20th internationally on number of graduate degrees awarded in engineering, computer science and mathematics—areas of expertise which are essential to being globally competitive (2004). And to emphasize the urgency, the Bureau of Labor and Statistics projects that by the year 2016, the United States will need an additional 15,600,000 information sector workers (2007).

Why is the United States falling short? Many factors are contributing to the decreasing success in math and science, but three are clear:

- Teachers have been given guidelines for meeting education initiatives, but need help with applying them in the classroom.
- Students have an increasing amount of information to process and don't have the skills to understand complex concepts or manage the data.
- Math and science are not being learned in a meaningful way and therefore are not retained.

To address these challenges, this white paper will:

- Provide a summary of research supporting the use of technology to meet STEM (Science, Technology, Engineering and Mathematics) initiatives and 21st century requirements.
- Show how the combination of visual learning and digital tools improves analytical skills, and information and data management.
- Offer examples of how real classrooms are using digital visual learning tools from Inspiration Software.

How the United States is addressing the shortfalls

In response to growing concern surrounding the need for 21st century skills, the U.S. Department of Education and other organizations are taking action to increase the United States' standing in STEM:

1. The Partnership for 21st Century Skills has stated that, "all Americans, not just an elite few, need 21st century skills that will increase their marketability, employability and readiness for citizenship," such as:

The NETS include standards for using digital tools to manage, gather, evaluate and synthesize information.

- Thinking critically and making judgments [in the face of information overload]
 - Solving complex, multidisciplinary, open-ended problems [after first identifying the problem]
 - Communicating and collaborating
 - Making innovative use of knowledge, information and opportunities [to create new services, processes and products]
2. From the International Society for Technology in Education (ISTE), The National Education Technology Standards (NETS) call out the use and understanding of data and information as core components at several grade levels. The NETS also include standards for using digital tools to manage, gather, evaluate and synthesize information. These skills include the ability to:
- plan strategies to guide inquiry
 - locate, organize, analyze, evaluate, synthesize and ethically use information from a variety of sources and media
 - evaluate and select information sources and digital tools based on the appropriateness to specific tasks
 - process data and report results
3. Science will be added to the 2009 National Assessment of Educational Progress (NAEP) for three successive assessments at grades 4, 8 and 11. Topics include earth and space, physical, and life science.
4. In 2008, the NCLB (No Child Left Behind) Act began requiring testing in science in addition to the existing mathematics testing requirement.
5. At the local level, states are increasing their graduation requirements in math and science. The average requirement per state is now three years for math and 2.7 years for science. Many states are requiring testing either as end of course testing or end of 11th year testing. By 2015, 15 states are expected to require these kinds of math and science capstone tests for graduation, up from just four states in 2007, while 18 states will be requiring comprehensive exams specifically covering science. Forty-eight states have implemented technology requirements.

These initiatives provide goals for teachers and students, but teachers must determine the best path to achieve them. What tools are available to help them meet these expectations?

Research validates the use of technology as a means to prepare for success in the 21st century and increase critical thinking and data management skills.

Using technology to build students' information management skills

Students need to be able to easily manage and use information personally and professionally in the 21st century. Skills such as the ability to collect, analyze and understand data and information support good decision-making and are key to their success.

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The best learning occurs when real world problems are paired with real world tools for problem solving. As technology is an integral part of 21st century students' realities, these tools need to be digital to be relevant. When used for mapping, digital tools elicit problem solving behaviors in students which persist even when students are not using them (Chmielewski and Dansereau, 1998).

In order to meet the expectations of students who live in a technology-rich environment, the classroom must provide interactive opportunities which motivate and allow them to focus on learning the content rather than the task. With the overwhelming amount of information students are expected to absorb from textbooks, class discussions and other resources, they need simple and accessible ways to organize and process information and their ideas about it. Instead of conducting analysis using paper and pencil, creating graphs digitally removes the focus on the lower-level task of plotting the graph and allows students to apply higher order skills to understanding the science in their experiment (Rogers, 1995). When working with a variety of information, experimenting with multiple graph types easily and in real time maintains student interest and encourages engagement. In a study by Nafiz Osman and Jazlin Ebenezer (2007), students' attitudes toward and confidence about science improved when they used technology during their lessons.

Janet Sturm and Joan Rankin-Erickson (2002) compared four elements of essay writing using computer-generated concept maps: number of words, syntactic maturity, number of T-units and holistic writing scores. Students who created computer-generated maps scored higher, wrote more and felt better about their writing than the students who created hand-drawn maps, or used no specific tools. Students said they preferred the computer-generated maps because the hand-drawn maps were too sloppy, too hard to modify and the page became confusing without an easy way to organize the information.

The combination of visual learning and digital tools improves analytical skills and information and data management

Visual learning techniques include the use of digital technology to create diagrams, such as concept maps and webs, and use graphs, charts and images for analyzing and communicating information. Visual learning has been shown to improve:

- Reading comprehension
- Student achievement across grade levels, diverse student populations and content areas
- Thinking and learning skills such as organizing and communicating ideas, seeing patterns and relationships, and categorizing ideas
- Retention

Further research validates graphs and charts as an important component in conveying scientific information (Rogers, 1995).

For students struggling with abstract ideas, the ability to transform data or numbers into a visual representation using graphs or webs assists them in gaining a fuller picture of what they are learning. Howard Gardner found that children he identified as “spatial” learners tend to associate things on the basis of recognizing patterns in their physical qualities (1993). As students begin to web information and create maps of their ideas by moving them close to one another, a visual pattern or hierarchy begins to emerge. Creating these patterns, or maps, is a strategy to learn, organize, comprehend and recall information (Anders and Beech, 1990).

One way to gauge student comprehension is to measure how well they understand the context of a problem or a topic. Vonnie DiCecco and Mary Gleason’s study (2002) on the use of graphic organizers and student improvement found middle school students who chose to use graphic organizers as a study tool when reading expository texts such as lab procedures, government documents and journals had increased test scores.

When it comes to data handling, The Partnership for 21st Century Skills lists a variety of goals for students to become information and media literate. These include the ability to analyze, access, manage, integrate, evaluate and create information in a variety of forms and media (2007). Further, to become skilled at solving problems and develop thinking skills, students need to identify or formulate a problem, analyze the data, and find a solution. Across all subject areas, it is crucial that students gain the ability to synthesize large amounts of information into a coherent format and communicate the information clearly.

Thinking critically and making judgments are core 21st century skills. With information everywhere, the ability to accurately interpret data is necessary to assure that students don’t just accept everything they are told or see in print (De Rycker, 2001). Howard Wainer (1990) said, “seeing data in a graphical display allows students to discover patterns and recognize meaning about

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*—Onwuegbuzie, 2008
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data that might not be readily seen in a table or text. Graphs can easily show elements that might not have been seen otherwise.” (Onwuegbuzie, 2008). Once students understand these patterns, they are empowered to test the data, find new conclusions, and communicate those relationships, trends, or patterns to others. (Chick, 2004)

Digital tools from Inspiration Software address STEM initiatives and 21st century requirements

Inspiration Software offers two software programs which combine visual learning and digital technology.

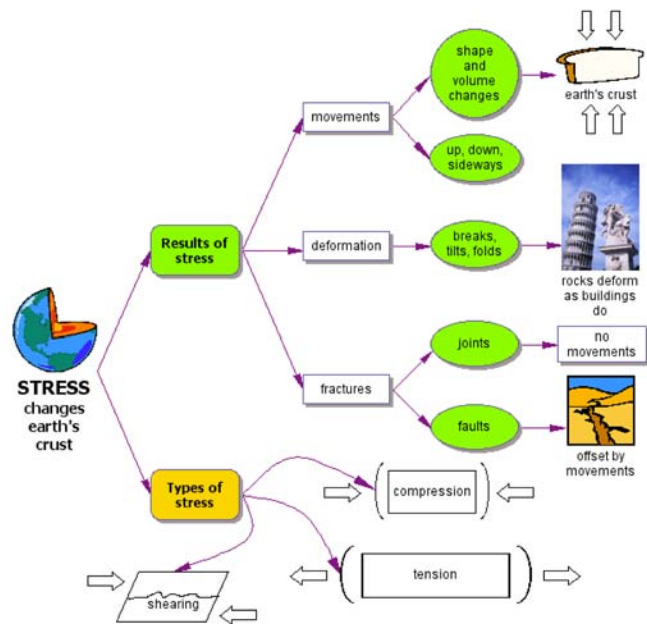
Inspiration

Inspiration is a visual learning tool used by 6-12 grade students in science, social studies and language arts. Inspiration helps students to take notes, brainstorm and synthesize their ideas into diagrams or outlines. As part of their research on computer-based study strategies, Leigh Zeitz and Lynne Anderson-Inman (1993) observed students using Inspiration to do mapping in preparation for a science test, and found that those with the best scores also created the most complex maps with many nodes and links. As a result, they concluded that because students were able to show the connections and see the relationship between ideas, they were able to develop a more complete understanding of a concept .

At Pope John Paul II, a pre-K through 8th grade school in Lecanto, FL, Principal Lou Whitaker invited students from a history class to the school’s computer lab, where she introduced them to Inspiration and led them in creating a map of the content from a chapter they had read to prepare for a test. After determining the main idea, they placed subtopics and supporting details into the diagram. However, the students ran out of time with only half of the chapter mapped out, so they did a quick review of the Inspiration diagram and left to take the test. When Whitaker examined the students’ test results, she found that the students had earned A’s on the first half of the test and F’s on the last half. They knew all the answers from the part of the chapter that was diagrammed in Inspiration. “They could see the diagram in their minds and remember the connections between the information,” said Whitaker. “But when they came to questions from the last half of the chapter, they couldn’t recall what they had read.”

Tom Stahley, of Skyview High School in Billings, MT, introduced his 9th and 10th grade students to Inspiration as a note-taking tool after some disappointing test scores on a science unit. After learning about Inspiration and graphic organizers, the students read a second science unit and used Inspiration to take notes. Stahley found that an astounding 81 percent of the students were able to organize information more effectively, and when tested on the material, 36 percent showed improvement on their test scores.

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Graphic organizers created in Inspiration helped Tom Stahley's students study more effectively and get better grades on their science tests.

Students can also use Inspiration's outlining capabilities to organize their research on a historical topic or time period, and then transfer their work to a word processor to develop it into a paper.

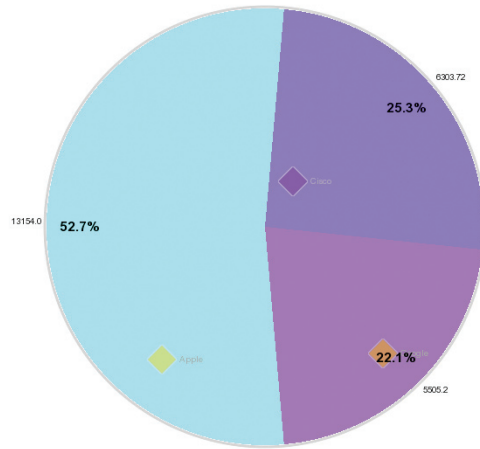
InspireData

Critical to understanding data is the ability to manipulate it in such a way that best represents its true meaning. InspireData, a tool which automates the creation of charts and graphs, is used by students in grades 4-12 to collect and analyze user-generated and public domain data. The ability to see the data in different graphical representations encourages students to ask meaningful questions and helps them solve problems, leading them to a better understanding of the results. Instead of plotting data by hand, which can be time-consuming and cumbersome, a digital tool like InspireData allows students to fluidly navigate between different graphs to find the best representation. And because computer-generated graphs are more precise, the students are better informed (Rogers, 1995).

In Wyncote, PA, Ancillae Assumpta Academy technology coordinator Melinda O'Neill and math teacher Jeanne Hisey chose InspireData for a middle school math project because it met a state standard on graphing and students could use it to collect data on a current topic. "When teaching math, we need to show students how it can be used in their daily lives," said Hisey. The students were told they each had \$25,000 to spend on a stock of their choice, which included companies such as Juicy Couture, Coca Cola, Nike and McDonalds. Over the course of three weeks, students used InspireData to create a line graph revealing how their stocks changed each week. "The students could see in living color how each stock was changing, looking at price over time," said O'Neill. "They could see how the market fluctuates." At the end of the

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three weeks, O'Neill created bar graphs of the students' investments, and the class examined the data by student and by stock. They looked at the stocks that had the greatest gains and losses, which prompted a discussion about making wise investments. "Without InspireData, we would have been building graphs by hand, which is very time-consuming. When they were done, they had something they were very proud of," said O'Neill.



Creating pie charts allowed the students to see the total dollar amount spent on each individual stock, as well as the percentage of students who had chosen that particular stock.

Commonly associated with the scientific method, generating and testing hypotheses is a research-based strategy for increasing student achievement which teachers can use across all disciplines (Marzano, 2001). Tasked with adding earth sciences to the curriculum to meet district exit exam criteria, chemistry teacher Glenda Schmidt of Slidell High School in Slidell, LA, set up a data analysis project called "Mapping the Air in Your School," in which students hypothesized and then measured the relative humidity and temperature in different rooms around the school. The students used InspireData, digital temperature probes and graphing calculators. "The students were extremely involved in the collection and interpretation of data," said Schmidt. "Because InspireData yields changes in visible results so quickly, it facilitates more questions and much more critical thinking."



Students chose an axis plot to show the correlation between a room's temperature, relative humidity, and whether or not it had a window heating unit.

InspireData is also unique in its ability to create an animated time series (line graph), which helps students to understand trends over time. With InspireData, students can easily translate data digitally to multiple graph types, change the scale, customize with colors and icons, and add different statistical measures, until they find the representation that best answers their questions.

Conclusion

For the United States to be internationally competitive in science, math and technology, and for students to succeed in the 21st century, digital tools must be used in the classroom to their full advantage. By combining visual learning and technology, Inspiration and InspireData provide students with the analytical and organizational skills to effectively process information and data, understand complex concepts, and make informed decisions.

About the Author

Sue Collins, Principal, CollinsConsults

Sue Collins brings over 35 years of experience in the education and technology fields. Sue began her career as a frontline educator, spending 5 years teaching science at the junior high and middle school level. After serving as the district science coordinator, she became Director of Instructional Services and Technology for the Washington State Superintendent of Public Instruction.

In the private sector, Sue has held senior-level marketing, professional development and general manager positions with Apple Computer, Compaq Computer Corporation, Jostens Learning Corporation and bigchalk.com. Sue served as Chief Education Officer at Apex Learning.

Sue is well-known for her ability to bridge education, technology and public policy. In 2000, she was appointed by President Clinton to the Web-based Education Commission. In testimony before Congress, she has represented both the SIIA and the Web-based Education Commission. Most recently, she testified before the FTC regarding interstate barriers to online courses and eLearning, and she wrote "eLearning Framework for NCLB" for the U.S. Department of Education's National Educational Technology Plan, released in 2004.

Sue holds a bachelor's degree in General Science and a master's in Earth Science from Oregon State University.

She currently consults with education and technology businesses.

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