SCIENCE FUSION

The Benefits of the Technology and Multimedia Features of the ScienceFusion Program: A Research Base

HOUGHTON MIFFLIN HARCOURT

SCIENCE FUSION

Contents

The Purpose of this Document

Houghton Mifflin Harcourt *ScienceFusion*, designed for students in grades K through 8, is an interactive science program that delivers a holistic science experience, based on investigation and application across print, digital, and hands-on resources. The purpose of this document is to demonstrate clearly and explicitly the scientific research base upon which the digital components of the ***ScienceFusion*** program are built. The program was designed following the principles of effective multimedia instruction in order to harness its potential for all students, and for learners of science in particular.

This report is organized around three strands: 1.) the benefits of multimedia learning, 2.) the advantages of multimedia learning for teaching science, and 3.) the principles of effective multimedia design. To help readers make the connections between the research and the **Houghton Mifflin Harcourt *ScienceFusion*** program, the following sections are used within each strand:

- **Defining the Strand.** This section summarizes the terminology and provides an overview of the research related to the strand.
- **Research that Guided the Development of *ScienceFusion*.** This section identifies subtopics within each strand and provides excerpts from and summaries of relevant research on each subtopic.
- **From Research to Practice.** This section explains how the research data is exemplified in the **Houghton Mifflin Harcourt *ScienceFusion*** program.

The combination of the major research recommendations and the related features of the **Houghton Mifflin Harcourt *ScienceFusion*** program should help readers better understand how the program incorporates research into its instructional design.

A complete reference list of all works cited is provided at the end of this document.

Introduction to Multimedia Learning

The case for multimedia learning is based on the idea that instructional messages should be designed in light of how the human brain works. (Mayer, 2001, p. 4)

Learning involves many systems and processes in the human body, in particular, the brain and central nervous system, which comprise the cognitive network. Piaget (1953) is often credited with drawing attention to how cognitive systems function within children, and performed some of the pioneering research examining the extent and limitations of children's cognition. Building on this research, modern cognitive theory is often the center of research endeavors in education. According to this "science of learning," a learner's knowledge is maintained in networks of interconnected ideas and concepts and acquiring new knowledge is a function of perceptual abilities, attention, motivation, prior knowledge, and attributes of the material being taught (Sweller, 2003).

Educators cannot impact their students' biology, which contributes, somewhat, to the functioning of students' cognition; however, educators do have the ability to affect student learning by how they present material and through the learning environment they create using different instructional practices. One environment for learning, which has been shown to have great promise for student achievement, is the multimedia environment. To understand how educators can create a multimedia environment that optimizes student learning, cognitive psychologist Richard Mayer proposed his Cognitive Theory of Multimedia Learning (Mayer, 2001). Simply stated, Mayer (2001, 2005) argues that student learning is increased when students are presented information using multiple presentation formats, in particular, words/audio and pictures. Because the cognitive system has different memory structures that are sensitive to these various presentation modes, students have a greater likelihood of encoding information and retaining this information when it is presented using a combination of forms of instruction (i.e., the multimedia principle). While teachers can utilize a variety of different tools to engage in this multimedia learning, schools throughout the United States have increased the adoption and use of different digital and technological tools, such as computers, multimedia presentations, and high-speed internet for educational purposes (Gray & Lewis, 2009).

Thus, it is appropriate that teachers harness these new tools to engage in multimedia learning. Along with traditional lecture practices, teachers now can use video, audio, PowerPoint®, and have a host of animations, simulations, and other interactive content available via the internet. But, because all learners are sensitive to "cognitive overload" (Sweller, 2005), simply providing content using many different digital tools is no guarantee that student learning will be improved. Simply exposing students to some (or all) of these distinct educational practices does not necessarily lead to improved student performance. Rather, teachers need to appropriately use the various presentation modes that are available to them to ensure student learning is optimized.

Based on years of scholarly work (Mayer 2005), researchers have concluded that a multimedia learning environment should:

- Combine visual/animation elements with auditory/verbal elements.
- Avoid redundant narration and on-screen text.
- Place corresponding images and text close to each other on the screen.
- Show images and play related sounds simultaneously.
- Include relevant pictures, texts, and sounds—and exclude those that are irrelevant.

As Mayer & Johnson (2008) indicate, the tenets and principles of the Cognitive Theory of Multimedia Learning (Mayer, 2001) were not intended to be a series of "rigid laws that must be followed in all circumstances. Rather, decisions about appropriate instructional design should be based on an understanding of how people learn from words and pictures…" (p. 385). Therefore, research described throughout this report describes the elements—and effects—of well-designed multimedia programs for learning.

Multimedia Learning in *ScienceFusion*

In ***ScienceFusion,*** students advantage themselves of the benefits of multimedia instruction.

While all of the program's print resources are located online at point of use for ease of access, the program's digital path goes far beyond access to the print content. Instead, the digital lessons are complements to the print lessons, designed so that teachers can customize their combination of print, digital, and inquiry activities to best meet their students' needs. Every lesson in ***ScienceFusio***n is designed to be accessed in multiple ways.

The digital path of the program is designed to use technology to best meet learners' needs—to be flexible, to allow for interaction, to be engaging and motivating, and to reach a wide range of learning styles (employing visual, kinesthetic, auditory, and verbal modes) and abilities.

The **eLearning Curriculum** engages students and activates their different paths of learning with interactive features, embedded video, and clickable write-in responses. **Digital lessons, Virtual Labs, Video-based Projects,** animations, simulations, and access to eTextbooks all harness the power of multimedia to increase learning and engagement.

Digital Lesson

Virtual Lab

To align with what researchers know about effective multimedia learning, the ***ScienceFusion*** program:

- Combines visual, auditory, and verbal elements.
- Avoids redundancy.
- Connects application at the point of learning.
- Focuses on relevant information—and excludes what is irrelevant.

Students are often not familiar with formal science writing forms and methods, and need instruction and practice using these forms to become proficient. Students need to learn the assumptions, procedures, and purposes of scientific writing in order to fully understand the scientific method, explanation, and justification. Knowing these rules allows learners to build conceptual understanding and "construct relationships among ideas" (Klein, 1999, p. 230). Michaels, Shouse, and Schweingruber (2008) found that "science-specific forms of argumentation" are different and students need instruction in how to correctly postulate a scientific argument in their writing (p. 89).

Strand 1: Benefits of Multimedia Instruction for Learners

…the goal of multimedia presentations is not only to present information, but also to provide guidance for how to process the presented information—that is, for determining what to pay attention to, how to mentally organize it, and how to relate it to prior knowledge….multimedia is a sense-making guide—that is, an aid to knowledge construction. (Mayer, 2001, p. 15)

Defining the Strand

While there are individual differences and variations among learners, all individuals benefit from multimedia environments designed to enhance learning. The use of computers to create multimedia environments is a natural extension as these digital tools can provide rich, varied instruction that is engaging and advances student thinking (Goldman-Segall, 1998).

Multiple research studies have investigated the use of computer and digital tools to enhance learning and found that the use of computers improves student learning (e.g., Britt & Aglinskas, 2002; Teh & Fraser, 1995). A 2003 meta-analysis of 42 studies with 282 effect sizes and combined sample sizes approaching 7,000 students concluded that technology had a positive and significant effect on student outcomes (cognitive and affective) when compared with traditional instruction (North Central Regional Educational Laboratory, 2003). These findings were supported by the more recent findings of a U.S. Department of Education meta-analysis of studies that 1.) contrasted online and face-to-face learning, 2.) measured student learning as a result of the two conditions, 3.) were rigorously designed, and 4.) generated adequate data to calculate an effect size. In an analysis of the resulting 51 independent effect sizes, students in online conditions were found to outperform those in more traditional environments, with the most significant differences between students in traditional classrooms and those in blended conditions, in which students received instruction that combined online learning with additional face-to-face learning time (Means, Toyama, Murphy, Bakia, & Jones, 2009).

The **Houghton Mifflin Harcourt *ScienceFusion*** program was designed to provide all students with ample guidance as they learn scientific concepts and skills. The program harnesses the power of technology and computers to provide dynamic, multimedia learning environments that students need to understand complex scientific concepts and relations. The opportunity for teachers to use the print path or digital path with the inquiry strand—or to combine the paths—provides the blended educational approach that has been shown to be the most effective teaching model in 21st century classrooms. Using these tools, educators can customize instruction for particular students and modify learning contexts so educational opportunities can be tailored to meet students' needs. Using ***ScienceFusion*,** teachers utilize the different paths to build meaningful learning experiences and provide the appropriate graduated instruction and experimentation that is necessary for learning science.

Research that Guided the Development of *ScienceFusion*

Multimedia Can Meet the Needs of All Learners

The research is clear; technology in the classroom can support learning for all students, including average learners and those who are below average (Becker, 1986). Students struggling with complex scientific concepts can benefit from computer-based learning environments with the largest effects on student learning occurring when the material to be taught is complex; in fact, the more complex the material that is being taught, the greater the benefit of using technology (Holzinger, Kickmeier-Rust, & Albert, 2008). Huppert, Lomask, and Lazarowitz, (2002) also reported that using computers for low performing science students enhances their ability to understand science concepts and reason like scientists by mastering skills such as measurement, interpreting data, and designing an experiment.

Mayer's (2001) research on multimedia learning supports these findings—that all students, including low knowledge learners, benefit particularly from well-designed multimedia learning environments. In fact, Mayer and his colleagues (1995) compared the impact of multimedia instruction with that of text-only instruction. Knowledge retention was significantly greater among those students categorized as "low-knowledge" learners (Mayer et al., 1995). Adherence to the principles of effective multimedia design are most essential for low-knowledge and high-spatial learners. For these students, the impact of effective design is greater than for those who have high prior knowledge or low spatial abilities (Mayer & Moreno, 1998). Computers can assist in meeting the individual needs of students with special needs, by embedding supports that can be used as needed by students. These scaffolds can take many forms, such as activating prior knowledge, modeling, questioning, or providing cues or tools for students (Stone, 1998).

Other student subpopulations that traditionally underperform in science can significantly improve their science skills by using computer technology. Researchers have shown that the achievement gap between boys and girls in science can be made smaller by computer-based instruction, with these effects attributable to girls' ability to learn material at their own pace and in a non-competitive situation (Huppert, Lomask, & Lazarowitz, 2002). Further, in a research study of the impact of an inquiry-based, computer-enhanced, middle-school science program on urban middle school students, researchers White and Frederiksen (1998) concluded that these instructional methods could be utilized in urban schools and lead to improved student achievement, with such methods being more effective among students who were educationally disadvantaged. Further, Braun et al. (2009) indicated that minority students are significantly less likely than whites to report being exposed to active learning experiences, which have been found to be associated with improved student achievement, including modeling demonstrations via digital or online virtual laboratory. These researchers argue that the achievement gap between minority and white students could be decreased by increasing the occurrence of these educational multimedia learning environments within minority student science classrooms.

Multimedia Can Support Metacognition and Increase Motivation

Metacognition is thinking about thinking. Some basic metacognitive strategies include connecting new information to that previously learned, selecting thinking strategies purposefully, and planning, monitoring, and evaluating thinking processes (Dirkes, 1985). Studies show that the use of metacognitive strategies increases learning (e.g., Scruggs & Tolfa, 1985). Multimedia environments can also support the development of metacognition. For instance, White and Frederiksen (1998) found that students taught with a multimedia curriculum which included a metacognitive component had greater student achievement when compared to students not taught with this component.

One method to improve metacognitive reasoning is to scaffold instruction. Scaffolding is an educational technique that involves providing support to students as they learn, and gradually decreasing the amount of support provided until students are completing tasks independently. McNamara and Shapiro (2005) demonstrated the value of using digital agents for scaffolding. They found that digital agents could serve as mentors, providing strategic think-alouds to help students make connections between previously introduced material and new concepts, and thereby improving students' ability to grasp new concepts. Likewise, Zydney (2010) reported on the value of multimedia scaffold for learning. In one study, the inclusion of an organization tool as a scaffold improved student problem solving abilities, suggesting that students benefited from support in organizing their knowledge and presenting their findings. By scaffolding learning—making learning strategies explicit through think-alouds or providing an organizing structure for thinking about a problem—teachers support students' development of metacognition, which will enable them to recognize when such strategies will be useful for them in future learning situations.

The use of technology can also affect student engagement and motivation in the science classroom. In considering the connection between multimedia learning and increased student engagement, Reinking (2001) attributes increased student engagement to four specific characteristics of multimedia learning environments: the interactive nature of the medium; supportive scaffolds and accessibility of environments; concrete, game-like nature of the medium; and social learning aspects of computer-assisted learning. Other researchers have indicated that multimedia learning leads to increased student motivation because of the freedom of choice and self pacing that these environments provide and the engaging and active learning that is possible within these environments (Schunk, Pintrich, & Meece, 2008). These components of multimedia learning affect student motivation, driving students to be more likely to complete science tasks. For instance, Abdoolatiff & Narod (2009) discovered that students who completed a computer-based science lab performed significantly better on a test measuring understanding of the lab and reported increased motivation and enthusiasm for the material when compared to students taught the same material using traditional approaches. Further, using computer-based instruction in the science classroom is related to other motivational aspects, including increased value placed on the subject, students' improved perceptions of their abilities, increased student self confidence, and overall enjoyment (Ke, 2008).

From Research to Practice

The **Houghton Mifflin Harcourt *ScienceFusion*** program was designed to provide all students with ample guidance as they learn scientific concepts and skills.

The unique design of the program—with two parallel paths, the **Print Path** and the **Digital Path,** with the **Inquiry** strand woven closely into each—allows for teachers to customize their combination of print, digital, and inquiry to best meet their students' needs.

***ScienceFusion's* eLearning Curriculum** meets students where they are and enables them to learn in an effectively designed multimedia environment through simulations, animations, videos, virtual labs, video-based projects, and assessments. **Digital Lessons** and **Virtual Labs** offer an alternative digital experience for every textbook lesson, with the same content, vocabulary, and inquiry skills delivered in a completely different way. This gives students multi-modal and multiple exposure to all standards. These **Multi-modal Learning** options allow teachers to meet the specific needs of students who learn best visually, kinesthetically, or verbally.

With ***ScienceFusion*** all students can be reached via their unique learning styles.

Meeting the Needs of All Students in ScienceFusion

In ScienceFusion, components, resources, and design features such as the following help to meet the needs of all students:

- **Leveled Readers (K-5):** Three levels of a variety of leveled readers are available for each unit to support students' differentiated reading abilities. Students can be assigned an optimal leveled reader, designed to help students' reading accuracy, fluency, and comprehension, while challenging them to progress to the next level.

- **Leveled Inquiry Opportunities:** In ***ScienceFusion,*** labs are offered at three different levels, with varying amounts of instructor guidance needed, to meet the needs of all students.
    - o **Guided Inquiry** develops students' inquiry skills within a supportive environment.
    - o **Directed Inquiry** introduces inquiry skills to students within a structured framework.
    - o **Independent Inquiry** deepens inquiry skills with student-driven questions and procedures.
- **Interactive Glossary:** The glossary provides content-area vocabulary and definitions, with photographic or audio/video elements (in English and Spanish).
- **Student Vocabulary Cards (K-5):** The Editable Vocabulary Cards can be alphabetized as in the glossary or organized by unit; they can be downloaded by students or printed and distributed by the teacher.
- **Extra Support for Vocabulary and Concepts:** This digital-only worksheet resource provides students with extra practice of lesson vocabulary and main ideas.
- **Multi-Language Resources:** All ***ScienceFusion*** resources are available in English and Spanish. In addition, the 6-8 glossary is available as a **Multi-Language Glossary** with key terms and definitions in English, Spanish, Chinese, Vietnamese, Khmer, Laotian, Arabic, Haitian Creole, Russian, and Portuguese.
- **Student Edition Audio:** Students can listen to or download the full audio (in English and Spanish) of their textbook to MP3 players.
- **Scaffolded Instruction:** In ***ScienceFusion,*** technology supports the delivery of scaffolded instruction to meet all students' needs. Students are engaged through the strategic use of visuals and audio, and the human-like narrator that serves as a guide for students through the units and lessons. The computer prompts the learner, encouraging metacognitive reflection and review of main ideas. Students stay on task as they move through segments of learning, controlling the pace of their learning to ensure understanding before continuing. When students are ready for independence, online labs and activities are available, and online assessment provides the feedback students need to lead to improved, independent performance.

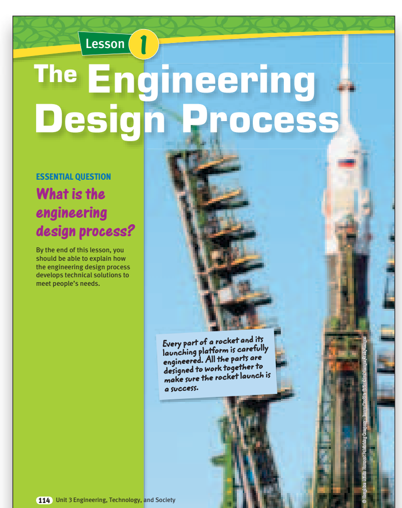
In addition, the ***ScienceFusion*** eTextbooks allow students and educators to access content on their electronic devices—with the functionality that 21st-century learners expect, including:

- Interactive Tables of Contents
- Zoom and Resize
- Scroll
- Text Search
- Web Search on Keywords
- Bookmark
- Dictionary Lookup
- Notetaking

Fostering Metacognition in ScienceFusion

The overarching structure of ***ScienceFusion*** was created to support students in thinking about their scientific thinking and reasoning—and building a cognitive framework for scientific ideas.

Within each grade level or module, ***ScienceFusion*** follows a clear structure that gives students a framework in which they can think about their own thinking in science. Each unit of the program is organized by a **Big Idea;** a broad, powerful concept that connects scientific facts and events. Within these **Big Ideas,** each unit is organized around **Essential Questions**. Each **Essential Question** identifies the conceptual focus of the lesson—and gives students a sense of direction and purpose for their learning. These **Big Ideas** and **Essential Questions** ensure that students have a clear framework for their learning and that their learning is purposeful.



Within these overarching organizing structures, throughout the program, students are asked to respond to prompts that ask them to engage in monitoring, and reflecting on their own learning and understanding. As students work through the program's **Digital Path, Active Reading** prompts, opportunities for highlighting and note-taking, and other ongoing checks on comprehension, students are provided with multiple opportunities to think about their thinking. Hands-on inquiry opportunities with every lesson (in the form of **Virtual Labs, Video-Based Projects,** and other opportunities) allow students to confirm their understanding through application.

And, finally, regular and ongoing opportunities for assessment encourage students to monitor their own progress and maintain an awareness of their own understandings. **Online Unit Self Quizzes** give students a view of their strengths and weaknesses in a given unit. In addition, digital assessment benefits include:

- Assignable leveled assessments for individuals.
- Customizable lesson quizzes, unit, and cumulative tests.
- Individual and whole-class reporting.
- Prescription tied to test questions.
- Audio for each **Online Assessment** test item in grades K and 1.

***ScienceFusion's* ExamView® Test Banks** allow teachers to customize a quiz or test by adding or deleting items, revising difficulty levels, changing formats, revising sequence, and editing items. Students can take these quizzes and tests directly online to assess their learning.

Motivating and Engaging Students in ScienceFusion

ScienceFusion was designed to engage and motivate students.

Research suggests that active learning engages and motivates students. The program's eLearning curriculum provides constant interactions through simulations, animations, videos, **Virtual Labs, Video-Based Projects,** and assessments. Throughout ***ScienceFusion's*** **Digital Lessons,** students remain engaged because they control the pace of learning—they click through vocabulary words and images to find facts and definitions. They navigate each page to replay for review, pause to take notes, or click next to continue. **Virtual Labs** and activities engage students in applying content that they have learned.

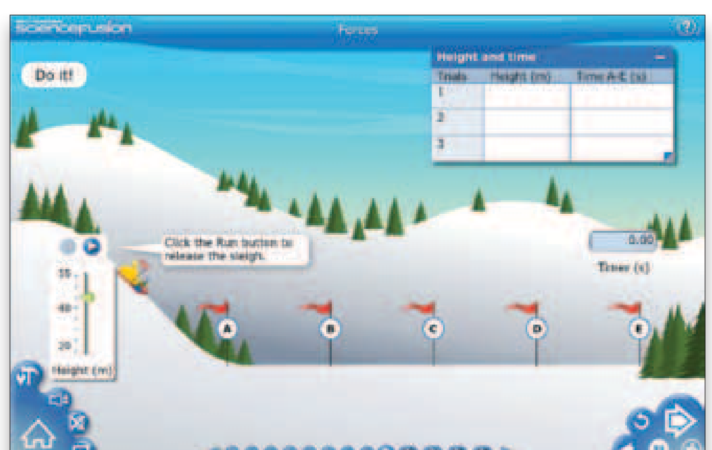
The interactive digital curriculum **Grade-Level or Module-Level, Unit-Level, and Lesson-Level Resources** engage students through specific components and features such as:

- **People in Science:** By making the content relevant and offering students meaningful contexts for learning, ***ScienceFusion*** engages students and motivates them for learning. The collection of multimedia biographies of scientists from past and present and descriptions of scientific careers can be found at the module level and at the point of use in each unit.

- **Video-Based Projects:** These inquiry-based projects consist of a video, teacher support pages, and student activity worksheets. There are over 20 included in ***ScienceFusion*** across grade levels and modules (several per grade in grades 3 through 5 and one or more per module)—focusing on STEM, Ecology, and Biotechnology. These are available online at point of use or on the Teaching Resources DVD.

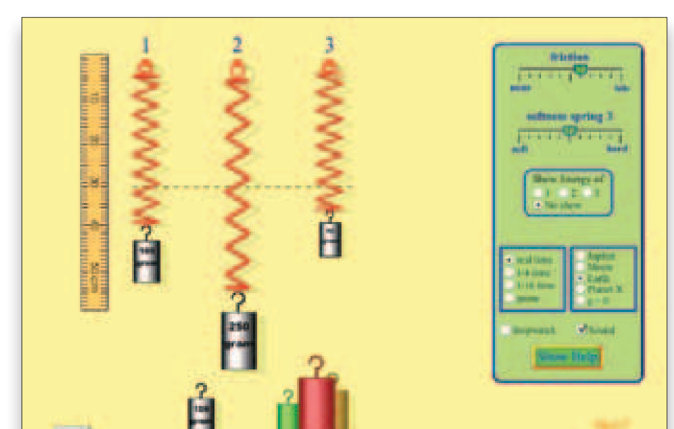
  For examples of **Video-Based Projects** in ***ScienceFusion*** see:

  - Grade 3
    Exploring the Galapagos Islands
    Take It to Great Heights
    Tent-Making Bats
  - Grade 4
    It's a Bird! It's a Plane!
    Rainforest Habitat
    Alligators Up Close
  - Grade 5
    The Sea Turtles of Shark Bay
    No Gas Needed
    Get Focused
    A Cut Above



  - Module A
    Photosynthesis
    An Inside View
  - Module B
    Expedition Evolution
    Animal Behavior
  - Module C
    A Prosthetic Hand
    Robotic Assist

- **NSTA® SciLINKS®:** Found at the point of use in each unit and vetted by scientific experts at NSTA, these resources engage, extend, and expand students' understanding of unit concepts and skills.



Strand 2: Advantages of Multimedia for Teaching Science

…a variety of technological applications can be used to enhance science learning, promote reflection, and build communities of learning…The diverse technologies then serve as integral tools that enhance teaching and learning beyond what traditional methods allow. (Dani & Koenig, 2008, p. 209-210)

Defining the Strand

In order to best provide students with scientific literacy and to prepare them for the demands of the 21st century, experts advocate the thoughtful and effective integration of digital technologies in science instruction (National Research Council, 1996, 2005, 2007); "Computers, for example, can be used in many ways—to facilitate drill and practice exercises or to provide access to powerful analytical tools and real scientific data sets, such as visualizations of real-time climate data" (NRC, 2007).

Working scientists use technology tools, including computer simulations, models of phenomena, and collaborative tools such as e-mail. Similarly, these tools can help students learn to think and act like scientists. We know that students learn best by doing, particularly in science class (Bransford, Brown, & Cocking, 2000; Dalton et al., 1997). Technological environments can better match how students learn in general, and how they learn in science specifically (Roschelle et al., 2000). A multimedia environment can support students as they engage in the scientific process, making predictions and posing questions, collecting evidence and recording data, thinking critically, and interpreting and communicating the results. Multimedia environments are particularly beneficial in helping students with the visualizing and modeling of scientific concepts that is so essential to science concept learning (e.g., Cifuentes & Hsiesh, 2004). Multimedia and technology-based tools should not replace hands-on experiences or traditional laboratories. Instead, they can provide students with repeated exposures and varied representations, thereby deepening their learning (Huppert, Lomask, & Lazaworitz, 2002).

The **Houghton Mifflin Harcourt *ScienceFusion*** program was designed with a learner-centered focus. Technology was not used because of its capacity as technology, but because of its capacity to help students learn science. In ***ScienceFusion*,** the technology path was designed and planned with a consistent focus on the goals for deep learning in the sciences and an understanding of how students best achieve these goals. Visuals and models were created using multimedia learning principles to aid students' understanding of complex concepts and relationships. Animations and simulations provide students with an opportunity to engage in active learning and apply and extend concepts they have learned during science instruction. Virtual labs were designed to be fully interactive and provide students a rich, genuine experience to replicate the activities scientists engage in when performing research.

Research that Guided the Development of *ScienceFusion*

Students Learn Better with Integrated Visuals and Models

According to the multimedia principle (Mayer, 2001), combing words/audio and visual presentations leads to greater student learning because students are able to use both forms of presentations to build mental representations of new information. It is no surprise that many scientific studies have demonstrated that students learn better when both pictures and words are used than when text is provided without visuals (e.g. Levin, Anglin, & Carney, 1987; Mayer, 1989; Mayer & Gallini, 1990). As Clark and Feldon (2005) concluded from their review of research in multimedia learning, properly utilizing this principle when designing instructional environments and curriculum can have great educational benefits as well as reduce the time it takes students to learn new concepts. While pairing pictures and words is more beneficial than either approach, other researchers have found that learning is increased when visual content includes animations. For instance, Rieber (1990) examined the effects of three levels of visual elaboration—no graphics, static graphics and animated graphics—and found that the most effective approach for teaching challenging material was the combination of text and animated graphics. Using these animations provides students with a dynamic visual that researchers have found is associated with greater conceptual understanding of scientific concepts (Bell & Trundel, 2008). Similarly, Webb (2005) argued that technology-based learning environments in science are especially conducive to conceptual change because of the increased opportunities computers provide for visualizing through simulations. Other researchers have indicated that computer-based visualizations and simulations are particularly helpful for students with low content knowledge and are most effective when scaffolds are built into these programs to guide students toward understanding the complex relationships (Cifuentes & Hsiesh, 2004; National Research Council, 2007).

Computer-based instruction is particularly helpful in the sciences, a content area in which modeling plays a crucial role to students' understanding. Students who might otherwise face challenges in visualizing phenomena and objects can harness the power of technology to aid in these visualizations. For instance, Barnett and his colleagues (2005) found that students who created and interacted with 3-D models showed greater learning about astronomy concepts. This computer-based modeling helps students to develop "understandings through their first-hand experience…" and examine "their understanding from multiple perspectives" (Barnett, Yamagata-Lynch, Keating, Barab, & Hay, 2005, p. 351-352). Dani and Koenig (2008) observed that the dynamic nature of virtual environments provides for models and simulation of "abstract or complex scientific concepts, phenomena, systems, or processes" (p. 205) which leads to increased active thinking, increased student engagement and student motivation, and the formation of deeper conceptual understanding.

Students Learn Better When They Are Engaged in Active Learning

Researchers point to the benefits of technology for active learning; simulations, models, and digital tools "create exciting opportunities for students to create, manipulate, and interact with their own constructions, which in turn supports them in developing understandings through their first-hand experience" (Barnett et al., 2005, p. 351). Active learning is not physical behavior; active learning occurs when students' cognitive activity is the most active (Mayer, 2001).

Roy and Chi (2005) cautioned that while multimedia environments have the potential to improve student learning, such learning can only occur if students are actively engaged cognitively when interacting with these technologies. When using digital technologies, students need to continually build and integrate new knowledge with their existing understanding if virtual environments are truly going to be effective.

One way to increase the active learning in digital environments is to include regular feedback, prompts, and questions (Webb, 2005). For instance, Davis and Linn (2000) found that when students were prompted to think about important ideas and to reflect on what was being presented in computer-based simulations, they were significantly more likely to understand and apply more scientific concepts than students who were not provided such prompts. Further, researchers at the National Research Council concluded, after an extensive review of the existing research, that studies "show that interacting with software prompts can help students articulate their understanding as well as provide rationales for decisions that they would otherwise not make explicit" (NRC, 2007). Similarly Aleven and Koedinger (2002) looked at the impact of self-explanation on student learning and reported that a computer-based approach of prompting students to generate self-explanations can support student learning in virtual environments, leading to significantly greater performance than when such explanations are not provided.

Students Learn Better When They Use Technology for Inquiry

According to Buczynski and Fontichiaro (2009), including technology in inquiry learning leads to students being more active learners, increases student application of science concepts, and builds cooperation skills. Use of technology-enhanced inquiry lessons is associated with greater student mastery of science. For example, Sun, Lin, and Yu (2008) revealed that students using Web-based inquiry lessons had significantly greater scores on a posttest designed to measure understanding of material presented in the lab when compared to students who completed the same lesson using traditional approaches. Similarly, Huppert, Lomask, and Lazarowitz (2002) compared the performance of students completing computer-assisted inquiry lessons to students completing a traditional "hands-on" inquiry activity with no technology component and found that both approaches led to significant improvement, from pretest to posttest, in science knowledge, but that lower performing students performed significantly better on the posttest after using the computer-assisted lesson. The authors suggest that this result might be from the additional support and flexibility virtual labs offer students with content knowledge and skills.

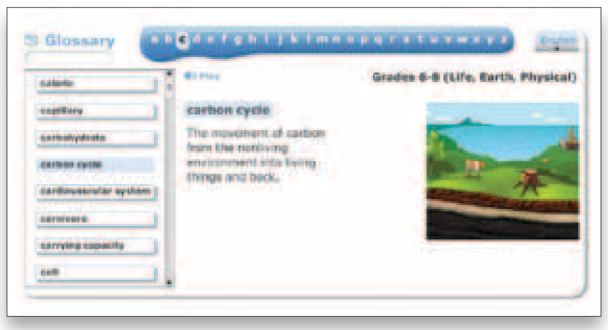
Research also indicated that students who complete computer-based inquiry lessons witness a significant increase in not only science knowledge, but application of science process, such as identifying variables and hypothesis generation (Tan, Yeo, & Lim, 2005). Some evidence indicates that combining elements of hands-on activities with virtual simulations leads to greater conceptual understanding than if only hands-on experiments are performed (e.g., Zacharia, Olympiou, & Papaevripidou, 2008).

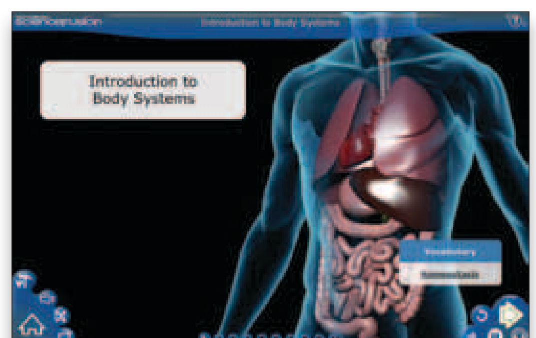
Another advantage of a technology-based environment for inquiry is the speed and simplicity with which students can engage in a virtual lab, thereby allowing them to focus more fully on the concepts learned (Webb, 2005). Also, virtual simulations provide students with the opportunity to be exposed to a wide variety of experiments they would not encounter because of costs and/or logistical reasons. When properly designed, these inquiry lessons encourage students to apply and extend their understanding of scientific concepts and use various critical thinking methods, which leads to improved science performance on achievement tests (Dani & Koenig, 2008). Just as real scientists are utilizing more technology when they perform research, science students should make use of these technologies to perform experiments, conduct secondary research, and communicate with one another to foster greater understanding and application of science knowledge. Therefore, computers can support the active, inquiry-based learning that is so essential in the science classroom; "there is compelling evidence that when classrooms function to support real scientific practice, students' understandings of science can flourish" (Michaels, Shouse, & Schweingruber, 2008, p. 127).

From Research to Practice

The **Houghton Mifflin Harcourt *ScienceFusion*** program was designed with a learner-centered focus. Technology was not used because of its capacity as technology, but because of its capacity to help students learn science. The **Digital Path** was designed and planned with a strong and consistent focus on the goals for deep learning in the sciences and an understanding of how students best achieve these goals.

In ***ScienceFusion*** students experience a multi-modal learning environment which fuses print, digital, and hands-on experiences. The technology components of the program allow for enhanced learning through the following.





Integrated Visuals in ScienceFusion

In order to help students integrate new science concepts with understanding, in ***ScienceFusion*****,** students are given numerous visuals and models to illustrate the concepts. Scaffolds and strategically inserted narration and animation help students to “see” the data and draw the correct scientific assumptions from virtual labs or online demonstrations.

In addition, the program’s **Interactive Glossary** visuals support students learning of content-area vocabulary.

By completing the **Video-Based Projects,** students learn through an active learning environment in which visuals and animation combine with audio and text to engage students and allow for application of content-area learning.

The **Media Gallery,** a Microsoft® PowerPoint slide presentation of key images from the *Student Edition,* can be used by the teacher or students to create their own presentations.

Self-paced and Active Learning Opportunities in ScienceFusion

Students engage in active learning on every page and with every activity in ***ScienceFusion***. Simulations, animations, videos, **Virtual Labs, Video-Based Projects,** and assessments all encourage active learning and interactivity through the digital design.

Throughout ***ScienceFusion’s*** **Digital Interactive Lessons,** students control the pace of learning—they click through vocabulary words and images to find facts and definitions. They navigate each page to replay for review, pause to take notes, or click next to continue. Inquiry is integrated throughout the program’s print and digital paths. **Virtual Labs** and activities engage students in actively applying content that they have learned.

Examples of design features and teaching and learning resources that illustrate the program’s commitment to active learning include:

- **Opportunities to provide feedback, respond to prompts, or answer questions:** Throughout the lessons, students are prompted with **Active Reading** suggestions, provided with opportunities to click through visuals or vocabulary words to learn more information, and given chances to move ahead or review content as needed.
- **Activities to ensure active learning:** Animation in the program engages students’ mental attention, and specific prompts and activities involve students in active learning tasks and situations. When engaged in simulated laboratory activities, students are prompted to take notes in their lab books, record observations, analyze data, and draw conclusions.
- **Online Unit Self Quizzes:** The self-assessment quizzes give students a view of their strengths and weaknesses in a given unit.
- **eTextbook:** The online *Student Edition* provides students anytime access to their print textbook. It is ready to use with an interactive whiteboard. Students can annotate on the screen, highlight, and underline.
- **Video-Based Projects:** These inquiry-based projects consist of a video, teacher support pages, and student activity worksheets.
- **Interactive Glossary:** The ***ScienceFusion*** **Interactive Glossary** provides program vocabulary and definitions with either photographic imagery or audio/video elements.
- **Student Vocabulary Cards:** The program’s **Student Vocabulary Cards** include short activities designed to help students actively understand and retain the meanings of vocabulary terms in the *Student Edition.*

Inquiry-Based Learning in ScienceFusion

The ***ScienceFusion*** program provides numerous resources designed to engage students in inquiry-based learning. Throughout the program, hands-on inquiry is woven into the print path and digital path. ***ScienceFusion*** teaches students the processes that scientists engage in when they experiment—and then provides opportunities for students to engage in experimentation themselves.

- **Virtual Labs:** Taking advantage of the benefits of instruction via computer, the program provides modeling and online virtual lab experiences for students. Labs are embedded with prompts that encourage students to engage in the scientific process – setting a purpose for their investigations, planning their procedures, recording their data, drawing conclusions, and generating further questions. Because of the possibility to engage in laboratory experiences much more efficiently online than in the traditional classroom, the program provides students with several virtual laboratory experiments in less time than they would be able to complete one hands-on laboratory in the classroom.

  For examples of Virtual Labs in Science Fusion see:

  - **Module A: Cells and Heredity**
    Virtual Lab, Unit 1, Lesson 3: *Cell Structure and Function*
    Virtual Lab, Unit 1, Lesson 6: *Photosynthesis and Cellular Respiration*
    Virtual Lab, Unit 2, Lesson 1: *Mitosis*
    Virtual Lab, Unit 2, Lesson 4: *Heredity*
  - **Module B: The Diversity of Living Things**
    Virtual Lab, Unit 1, Lesson 2: *Theory of Evolution by Natural Selection*
    Virtual Lab, Unit 1, Lesson 5: *Classification of Living Things*
    Virtual Lab, Unit 2, Lesson 4: *Plant Processes*
    Virtual Lab, Unit 2, Lesson 6: *Animal Behavior*
  - **Module C: The Human Body**
    Virtual Lab, Unit 1, Lesson 2: *The Skeletal and Muscular Systems*
    Virtual Lab, Unit 1, Lesson 3: *The Circulatory and Respiratory Systems*
    Virtual Lab, Unit 2, Lesson 1: *The Immune System*
    Virtual Lab, Unit 2, Lesson 2: *Infectious Diseases*
  - **Module D: Ecology and the Environment**
    Virtual Lab, Unit 1, Lesson 1: *Introduction to Ecology*
    Virtual Lab, Unit 1, Lesson 4: *Interactions in Communities*
    Virtual Lab, Unit 2, Lesson 3: *Energy and Matter in Ecosystems*
    Virtual Lab, Unit 2, Lesson 4: *Changes in Ecosystems*

- **Video-Based Projects:** Numerous inquiry-based projects are available online, along with teacher and student resources to support them.
- **Inquiry Flipcharts (K-5):** The flipcharts offer hands-on inquiry options for every lesson, allowing students to confirm understanding through application of concepts.
- **Online Editable Lab Manual (6-8):** Each ***ScienceFusion*** module comes with its own lab manual which includes:
  - **Quick Labs**
  - **Exploration Labs**
  - **Field Labs**
  - **S.T.E.M. Labs**
- **Opportunities to apply and extend concepts.** Throughout the digital path of the program, students are given opportunities to apply and extend concepts through think-along questions and prompts. By engaging student in these kinds of ongoing checks on comprehension, the multimedia environment engages students in actively learning to think like scientists.

Strand 3: Principles of Design for Effective Multimedia Instruction

The challenge for instructional designers is to apply design principles in ways that reduce extraneous processing (such as scanning between captions and the graphic), manage intrinsic processing (such as attending to relevant portions of the narration and graphic), and foster generative processing (such as mentally organizing and integrating the material). (Mayer & Johnson, 2005, p. 385)

Defining the Strand

As Mayer discusses in his 2001 book, *Multimedia Learning,* simply using computers does not necessarily lead to increased learning. The key is to use the technology in such a way that is consistent with how people learn; the design should be centered not around what the technological tools can do but on how the learners can best learn. When a multimedia environment is poorly designed, with extraneous information and ineffective presentation, students become overloaded cognitively and cannot process the new conceptual information (Wainwright, 1989; Sweller, 2005).

The overall coherence of an instructional message in a multimedia environment is important.

In a series of studies, Mayer (2001) investigated specific ways that multimedia learning could be designed to provide robust instruction that did not result in cognitive overload. He reported that the timing and placement of the integration of visuals with text is important, as is the use of audio to allow learners to gain knowledge through multiple channels. To create an effective multimedia learning environment, Mayer (2001, 2005) offers several "principles" to guide the design and implementation of different educational practices in the 21st-century classroom.

The **Houghton Mifflin Harcourt *ScienceFusion*** program was designed following the principles that research has identified as essential for learning in a multimedia environment. Throughout the K-8 program, these principles serve as the foundations for the structure of the learning environment. Visuals and text are coherent, presenting necessary and complete information–not irrelevant or extraneous information. Student labs and simulations were designed to ensure related concepts are presented in the same digital space so the screen appearance is not distracting. Teachers have wide options with program materials and content delivery and students have the ability to alter features, such as audio, to ensure that presentation modes meet students' learning styles. Finally, ***ScienceFusion*** was created so students have control over many elements of the virtual space, while they are engaged with meaningful questions and prompts to guide their investigation of simulations and inquiry lessons. These investigations build student ownership and enhance understanding and application of learned material.

Research that Guided the Development of *ScienceFusion*

The Modality Principle

The Modality Principle *states that students learn better from animation and narration (spoken text) than they do from animation and on-screen text. Presenting words auditorily allows students to process the "text" through their auditory/verbal channel and process the images via their visual/pictorial channel.*

As Schnotz (2005) summarized, many researchers "…have shown that students learn better when pictures are presented with spoken text instead of written text" (p. 61). The improvement in student learning is most likely the result of activating two memory systems—the auditory sensory memory, via the spoken word, and the visual memory system, by presenting relevant visual pictures (Mayer, 2001). Comparisons of multimedia learning environments in which text is presented via narration, to onscreen, visual presentations confirm that students learn more when on-screen pictorial presentations are accompanied by auditory narration (e.g., Craig, Gholson, & Driscoll, 2002).

The Spatial and Temporal Contiguity Principles

The Spatial Contiguity Principle *asserts that students learn more when corresponding words and images are close to each other on the page or screen. When words are placed far from corresponding pictures, learners must devote mental energy to scanning and making connections between pictures and words.*

The Temporal Contiguity Principle *refers to the idea that students will learn better when related pictures and words are presented at the same time, rather than sequenced one after the other. When images and corresponding text are separated by time, particularly a longer time, learners have more difficulty building connections between the two.*

Placement and timing of presentations are both important to students' comprehension of new material in multimedia learning environments. According to Schnotz (2005), "students learn better from words and pictures than from words alone, if the words and pictures are semantically related to each other (the coherence condition) and if they are presented closely together in space or in time (the contiguity condition)" (p. 60). Although the occurrence of text and pictures in a multimedia environment should be minimized, when they are necessary, such presentations of words and pictures should occur close to one another because "if we want students to build cognitive connections between corresponding words and pictures, it is helpful to present them contiguously in time and space…" (Mayer, 2001, p. 112). For instance, Mayer, Steinhoff, Bower, & Mars, (1995) performed a series of experiments examining the effects of text and picture placement on transfer problems of adding meaningful illustrations to support a scientific text. Their findings suggested that illustrations that were integrated with the corresponding text and contained annotations resulted in a 50% increase in solutions on transfer problems, particularly among students with less experience with the topic. The researchers concluded that "building a useful mental model of a scientific system depends on building integrative connections between verbal information selected from the text and corresponding features of images selected from the illustrations" (p. 39). Similarly, multiple studies have demonstrated that student learning is significantly improved when students view a simulation and accompanying narration at the same time, rather than experiencing the presentations separately (e.g., Mayer & Anderson, 1991, 1992; Mayer & Sims, 1994). Thus, pictorial simulations and the relevant auditory narration should be presented at the same exact time to ensure that these two distinct memory systems are processing the information together, leading to increased encoding and retention.

The Coherence Principle

The Coherence Principle *states that students will demonstrate greater learning when irrelevant material is not included. When learners' attention is focused on extraneous material, their attention is not focused on what we want them to learn. Including extraneous material can also divert students' focus, encouraging them to make misleading connections and organize their ideas around the wrong central ideas or themes.*

Earlier work on coherence was conducted with print texts, looking at the addition of interesting, but extraneous, details and their impact on readers' comprehension. This research indicated that irrelevant details interfere with learners' ability to identify and remember the main ideas of passages (e.g., Garner, Gillingham, & White, 1989). Similarly, a series of experiments conducted by Harp and Mayer (1998) found that students who read the passages with seductive details performed significantly worse on tests of reading comprehension than did students whose passages did not include the irrelevant information. Continued research supports these findings in a multimedia environment. Learners tend to learn less from presentations that include seductive details that are extraneous to the main idea or instructional goal of the presentation (Harp & Mayer, 1997, 1998; Mayer, Heiser, & Lonn, 2001). Seductive illustrations have the same negative impact on comprehension and retention that seductive text details do. The addition of seductive illustrations "hurt student learning of a scientific explanation," leading the researchers to "question the overuse in science textbooks of attention-grabbing color photographs that are not directly relevant to helping the reader make sense out of the explanation in the passage" (Harp & Mayer, 1997, p. 100).

More recently, Mayer, Griffith, Jurkowitz, and Rothman (2008) looked at the impact of extraneous details on students' understanding of scientific concepts presented through a multimedia science presentation. Specifically, this study looked at the impact of high-interest extraneous details versus low-interest extraneous details. Researchers found that high interest, but irrelevant information was more detrimental to student learning than low interest, extraneous material as students paid more attention to the information that was interesting, but not important. This engagement left them with less cognitive capacity to focus on important and relevant content. As Mayer and Moreno (1998) pointed out, while coherence is essential for maximizing learning, brevity is also important as "a shorter presentation primes the learner to select relevant information and organize it productively" (p. 5).

Similarly, irrelevant sounds and music affect student learning and understanding. In a series of experiments comparing learning from a basic version of a multimedia lesson with learning from a version with added sounds and music, Mayer (2001) determined that "students perform more poorly on verbal retention when background sounds and music are added to a multimedia explanation" (p. 126) and "adding background music and sounds resulted in poorer problem-solving transfer performance" (p. 127).

The Segmentation Principle

The Segmentation Principle *indicates that students retain more when information is presented in learner-paced units, rather than as a complete unit. Because all students have different prior experiences, the time it takes to incorporate new information into long-term memory varies for all students. Giving students control over the speed and presentation of new material increases students' ability to focus on material they are unfamiliar with and decreases time spent reviewing known content, improving overall student retention.*

Recent research has indicated that when students have control over virtual learning spaces, they are able to remember more and have significant improvement in learning when compared to the performance of students working in learning environments in which they have less control (Means et al., 2009). As Mayer (2005) indicated, "people learn more deeply when a multimedia message is presented in learner-paced segments rather than as a continuous unit" (p. 175). The principle suggests that the segmenting of units is important—as is learner control over the segments. That is, students should be able to control the pace of information, through a "Start/Stop" button or a "Continue" button. Researchers find that segmenting multimedia lessons using smaller parts and control features increases student retention because it places less demands on short-term memory, allowing students to make the connections between segmented material more easily than when material is presented as a whole unit (Lusk, Evans, Jeffrey, Palmer, Wikstrom, & Doolittle, 2009; Mayer & Chandler, 2001; Mayer, Dow, & Mayer, 2003). This segmenting of multimedia lessons not only provides educational benefits, but also motivates students to complete their work and improves student attitudes toward learning new material (Schunk, Pintrich, & Meece, 2008).

Guided Discovery Learning Principle

The Guided Discovery Principle *states that people learn better when guidance is provided in discovery-based multimedia environments. Providing different supports and prompts establishes a frame for learning and encourages learners to discover facts, content, and processes through their own investigations, leading to greater retention in long-term memory.*

According to de Jong (2005), scientific discovery learning is the process in which students "take the role of scientists who want to design theory-based empirical observations. Scientific discovery learning, therefore, is a complex learning method that consists of a number of specific learning processes" (p. 215). Such learning is necessary for students to understand how to employ the scientific process and make sense of experimentation and investigation in the science classroom. Computer technology provides an ultimate medium for such learning (De Jong & van Joolingenm, 1998). Discovery learning is improved through several multimedia learning enhancements, including guided discovery, in which students are routinely prompted to explain their work, answer questions, and provide feedback, which results in greater retention and application (Mayer, 1987). Technology can provide more (multiple types) of prompts that aid in students' science thinking and application of scientific knowledge, including demonstrating different modalities for real-world problems, presenting necessary information and feedback, providing students an environment in which to reason and solve problems, and giving students access to supplementary resources to increase efficiency (Lajoie, Lavigne, Guerrera, & Munsie, 2001). Various studies of guided discovery learning have shown the effectiveness of different types of scaffolds on student learning. For example, de Jong & van Joolingen (1998) found that assigning exercises such as questions and activities improved application of the scientific process, while Zhang, Chen, Sun, and Reid (2004) found that activities that encouraged reflection and provided students with concrete examples during digital simulation had a positive effect on student learning. Similarly, Moreno (2004) reported that multimedia agents that provided explanatory feedback reduced students' cognitive load, allowing them to learn more and demonstrate more interest and motivation than students who did not receive explanatory feedback.

Providing students with tools and access to domain-specific resources has also been found to positively affect student scientific discovery. For instance, Rieber, Tzeng, and Tribble (2004) examined students' interactions with a computer-based science simulation, and found that students provided with brief multimedia explanations of content gained significantly greater "implicit and explicit understanding of the science principles" (p. 307). Reid, Zhang, and Chen (2003) also found that providing access to the scientific knowledge base, through the form of a reference book embedded in the multimedia learning program, helped to support learners.

The Use of Pedagogical Agents

One way that multimedia environments have effectively guided students' learning is through the use of animated pedagogical agents—lifelike personas that serve as teachers or guides in a multimedia learning environment. These agents can move around the screen, direct students through gazes and gestures, and provide feedback—all to ensure that students pay attention to the information that is relevant to their task. As Atkinson (2002) reported, "an animated agent programmed to deliver instructions aurally can help optimize learning from examples" (p. 416). Research supports the use of well-designed agents to guide student learning. For instance, Lester, Convers, Stone, Kahler, and Barlow (1997) researched the effectiveness of an animated pedagogical agent in an early multimedia learning environment and found achievement was the greatest when students interacted with an onscreen agent providing high-level, spoken advice. Similarly, students report that multimedia presentations including animated agents and simulations are more entertaining and easier to understand (Andre, Rist, & Muller, 1999; Dunsworth & Atkinson, 2007). According to Laster, Stone and Stelling "...lifelike pedagogical agents whose behaviors are selected and assembled with a well-designed sequencing engine can effectively guide learners through a complex subject in a manner that exhibits both pedagogical and visual coherence" (p. 35). Moreno (2005) concluded that animated agents in computer-based learning environments who demonstrate personality characteristics and use a personal tone, addressing students directly with words like "you" and "we," engage students more than when an impersonal, more academic tone is used. Other researchers have found that a visual on-screen image is unimportant; students who learned by only hearing an agent's voice performed equally well as students who saw a life-like image on screen (Mayer, Dow, & Mayer, 2003).

From Research to Practice

The **Houghton Mifflin Harcourt *ScienceFusion*** program was designed following the principles that research has identified are essential for learning in a multimedia environment. Throughout the K-8 program, these principles serve as the foundations for the structure of the learning environment, as evidenced by the program's effective application of the principles.

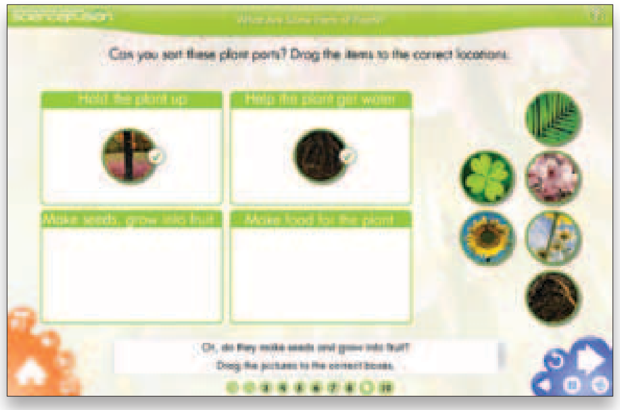
The Modality Principle in ScienceFusion

The use of a narrator to deliver content in ***ScienceFusion*** meets the design principle that Mayer (2001) has termed the ***modality principle.*** This principle suggests that because students can only take in a certain amount of information at one time in one way, or mode, multimedia environments should be designed to allow students to access information both by sight and by sound. The use of a narrator to deliver important content in the ***ScienceFusion*** program demonstrates the program's adherence to this key design principle. Students can listen to content, as they look at visuals and text on screen.

The Spatial and Temporal Contiguity Principles in ScienceFusion

The design of the ***ScienceFusion*** materials facilitates students' cognitive connections between words and images. In ***ScienceFusion,*** words and pictures are clearly connected. Words connected to relevant visuals keep students' attention focused on the important concepts.

Both the placement of images and text and the timing of their presentation were considered in the design of the ***ScienceFusion*** materials. Related pictures and words are presented at the same time so that students make connections between images and text.



The Coherence Principle in ScienceFusion

In ***ScienceFusion,*** only relevant material is included. The inclusion of only relevant content and visuals helps students to maintain a clear focus on relevant, important ideas.

Extraneous material is not included in the ***ScienceFusion*** program. Unnecessary animation and sounds are excluded—to keep students focused on the important facts and concepts. Background music, for example, is used to engage students at the very opening of the lesson, but then is not repeated throughout, so that students focus on the words and visuals—not distracting tunes.

The Segmentation Principle in ScienceFusion

In ***ScienceFusion,*** units are learner-paced.

The time needed to incorporate new information varies by learner. For this reason, in ***ScienceFusion,*** students have control over the speed and presentation of new material.

- By clicking on the page numbers at the bottom of the screen, students control the pace of the presentation.
- By clicking on the “Next” icon, students can continue to the next page.
- By clicking on the “Replay” icon, students can replay the audio.
- By clicking on the “Back” icon, students can go back to the previous page.
- By clicking on the “Pause” icon, students can pause.
- By clicking on the “Toggle Sound” icon and the “Closed Caption” icon, students can control how content is delivered—through audio or text.

The segments of lessons—where smaller units of content are delivered at one time or on a single screen—place less demand on students’ short-term memory. Placing less demand on short-term memory enables greater learning and retention.

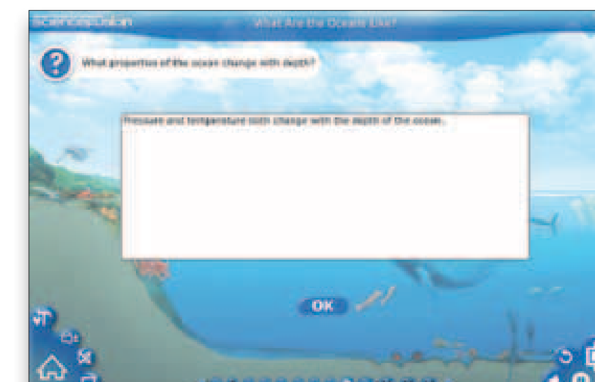
The Guided Discovery Learning Principle in ScienceFusion

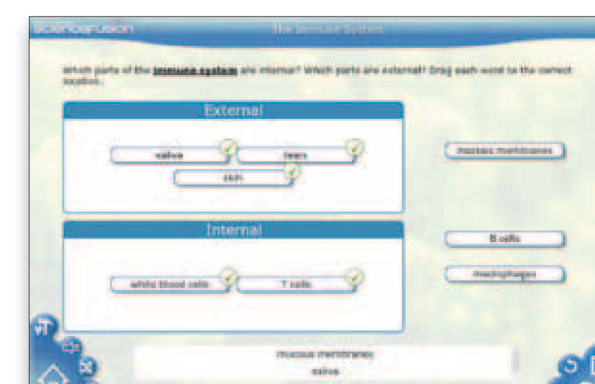
ScienceFusion follows a discovery-based learning model. In ***ScienceFusion,*** students take the role of scientists—employing the scientific process while conducting experiments and investigations. The program’s online labs, **Video-Based Projects,** and **Inquiry FlipCharts** all invite students to learn through active investigation and discovery.

In addition, throughout the ***ScienceFusion*** program, students are prompted to complete activities and answer questions to demonstrate their understanding and apply the new concepts they have learned.

To facilitate students’ discovery-based learning, ***ScienceFusion*** offers students the supports and resources they need to acquire new knowledge—including the following **Grade-Level** or **Module-Level Resources, Unit-Level Resources,** and **Lesson-Level Resources:**

- **Online Student Edition**
- **Student Edition Audio**
- **People in Science**
- **People in Science Gallery**
- **Video-Based Projects for Students**
- **Online Unit Self Quiz**
- **NSTA SciLINKS**
- **Glossary**
- **Student Vocabulary Cards**
- **Extra Support for Vocabulary and Concepts**
- **Inquiry FlipChart**
- **Student Handbook**
- **Leveled Readers 1, 2, and 3 (for grades K-5)**





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