Ideaphora

The Science Behind Ideaphora

Applying Insights From Research and User Activity to Online Knowledge Mapping

Dr. Lynne Anderson–Inman, Education Research Advisor

Anil Arvindam, CTO and Co-founder

Mark Oronzio, CEO and Co-founder

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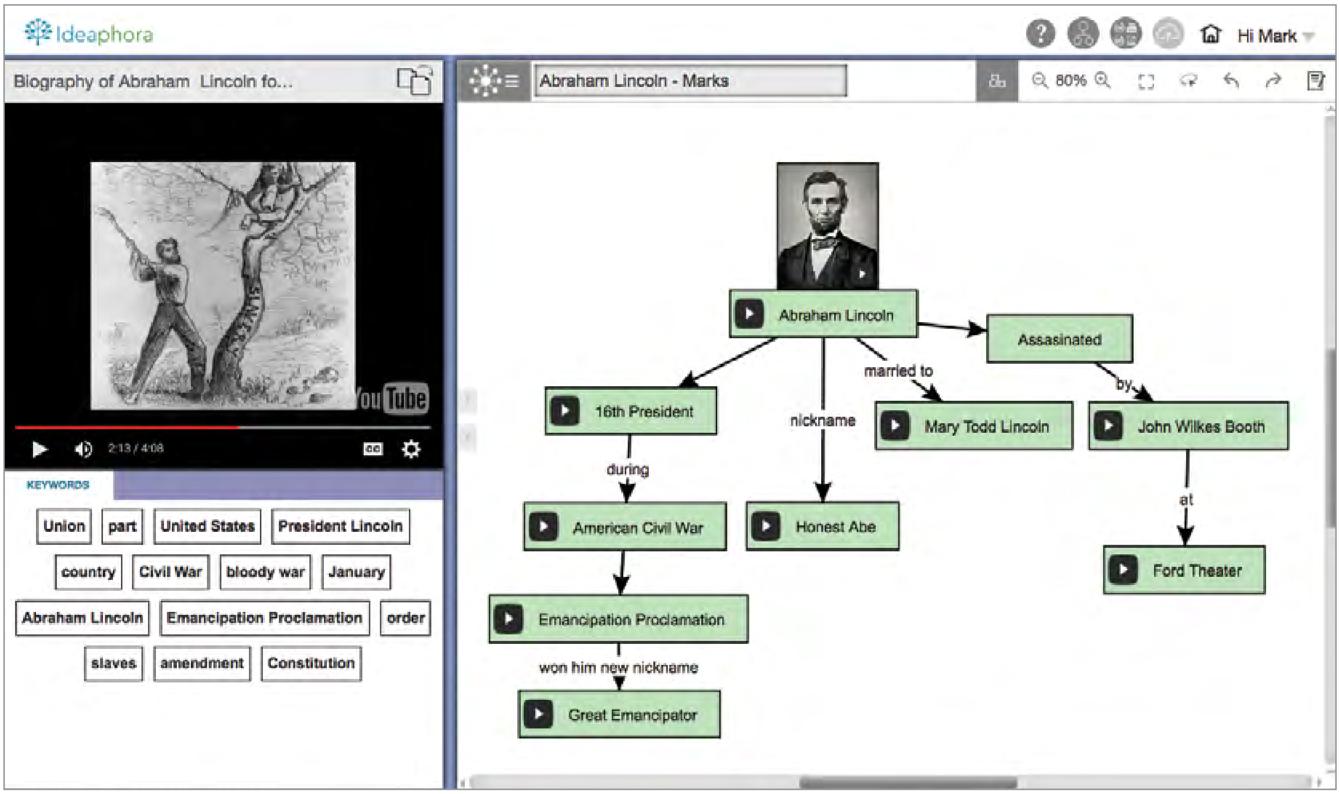
Ideaphora

Table of Contents

Summary



The Ideaphora web-based knowledge-mapping environment enables students, educators and schools to maximize the value of the growing array of digital content in ways that foster higher order thinking skills and a deeper understanding of subject matter. Ideaphora's system for semantic analysis deconstructs online content (e.g., videos, eBooks, websites) into meaningful concepts and then supports learners as they reconstruct the information into personalized knowledge in the form of visual maps of key concepts and their relationships.

Ideaphora has coupled insights from long-standing education research with innovative technologies to create an engaging digital environment for learners to build critical knowledge and skills. Ideaphora is also continuously improving its products based on data collected within its knowledge-mapping environment, plus continuous feedback from students and teachers.

Built on Strong Scientific Research

The Ideaphora knowledge-mapping environment is based on three strands of educational research: (a) Concept Mapping and Meaningful Learning, (b) Scaffolding and Supports, and (c) Making Thinking Visible. A brief overview for each of the three research strands is described below with supporting materials in the reference section.

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Concept Mapping and Meaningful Learning

The Ideaphora knowledge-mapping environment is the latest and most comprehensive tool for facilitating critical thinking through web-based concept mapping. It builds on decades of research investigating the use of concept mapping as an effective approach to fostering meaningful learning. In addition, it benefits from years of research experience designing and integrating technology- supported concept mapping in the classroom.

In 1956 Bloom proposed a taxonomy of intellectual behavior important for learning, with acquisition of knowledge at the bottom and evaluation of knowledge at the top. Decades of research on how to promote "higher order thinking skills" has led to a revision of Bloom's taxonomy and closer alignment with 21st century learning goals (Anderson, Krathwohl, et al, 2001). The lowest level of learning in the revised taxonomy is "remembering" existing knowledge and the highest is "creating" new knowledge—a differentiation in skill level also found in the Common Core State Standards. In response to the revised taxonomy Mayer (2002) advocated moving from instruction that focuses on retention of learning (remembering and understanding) toward instruction that fosters transfer of learning (applying, analyzing, evaluating, and creating)—in other words "meaningful learning." Key to the concept of meaningful learning is the learner's ability to link new ideas and information to prior experience and existing knowledge (Anderson-Inman & Ditson, 1999).

For more than 40 years, Novak and colleagues have advocated the use of concept mapping as an effective approach to fostering higher order thinking skills, moving students from mere knowledge acquisition to knowledge utilization and creation (Novak & Cañas, 2008). By specifying and linking concepts in a concept map, students create a visible structure of their understanding in a given domain that can be modified over time to assimilate new concepts and reflect new understanding. In short, concept mapping can move learners towards more in-depth learning, i.e., more meaningful learning by facilitating the process of linking new concepts with existing knowledge and experience.

Research on concept mapping reveals the process can have a powerful effect on learning. For example, Brullo (2012) found that students who created concept maps while taking notes had better test recall, could access information more quickly during tests, and scored better on content post-tests than students who did not have the concept mapping experience. According to Brullo (2012), students who created concept maps were thinking on a deeper level about the text prior to taking the post-test as these students quickly recalled information and answered the questions. Research also reveals that technology can play an important role in simplifying and supporting the creation, modification, and management of learners' concept maps (Chang et al, 2002; Liu et al, 2006; Liu & Lee, 2013).

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Scaffolding and Supports

Research-based scaffolds and supports are incorporated into the Ideaphora knowledge-mapping environment to promote efficient online learning and meet the needs of diverse learners. For example, to get started quickly, students can choose from a list of pre-selected domain specific keywords to use in their knowledge maps. Not distracted by the need to accurately type and spell, learners can focus on critical thinking. Easy manipulation of mapped concepts and their links gives students the flexibility to revise their knowledge maps as learning progresses. In addition, links between students' maps and source materials (e.g., video, eBook, website) facilitate subsequent review and clarification of conceptual connections. These and other features provide users with a supportive environment that fosters and helps structure learning.

The concept of scaffolded instruction emerged from the work of Vygotsky (1934, 1978) and Bruner (1973, 1978) on early language acquisition and the psychology of learning. Instructional scaffolding is an approach that promotes student learning by providing supports that help bridge the cognitive or performance gaps between what a student knows or can do and the instructional expectations of the teacher. There is an underlying assumption that the most effective scaffolded learning is one to one, where someone with expertise (the teacher, older student, expert) guides a novice to new levels of skill or deeper understanding. When learning occurs in a student-centered, digital environment, however, scaffolded instruction can be designed to meet individual needs without being so labor intensive, thus bringing the benefits of instructional scaffolding to more students more frequently (Lajoie & Azevedo, 2006). Brush and Saye (2001), for example, found improved learning when scaffolds were embedded in a student-centered, hypermedia learning environment.

Considerable research has been conducted on the types of scaffolds and supports most effective for student-directed online learning. For example, Anderson-Inman and colleagues in the National Center for Supported eText (NCSeT) have studied the use of "supported digital text" as an approach to increasing students' cognitive access to materials that might otherwise be difficult for them to comprehend (Anderson-Inman, 2009; Anderson-Inman & Horney, 2007). The different types of scaffolds or supports are categorized by the role they play in promoting learning. Ideaphora's knowledge mapping environment incorporates a variety of supports recommended by this research, including: (a) navigational supports (e.g., traversable links between knowledge maps and source materials); (b) illustrative supports (e.g., screen captured images to illustrate key concepts on a map; (c) notational supports (concept mapping that enables integrated note taking across multiple online media); and (d) evaluative supports (e.g., easy posting of maps for teacher or peer review).

Making Thinking Visible

Ideaphora's knowledge-mapping environment was designed to support the goals of making thinking visible. Underlying the process of knowledge mapping is the assumption that the resulting maps (whether called concept maps, semantic maps, or knowledge maps) reveal how a learner thinks about the material being learned – what concepts are important, how those concepts are related to each other, and what changes when new information is introduced. As such, knowledge mapping is one approach to externalizing the learner's thought processes and using that information to improve learning.

Studying ways to make thinking visible has been fundamental to multiple research projects over the last couple of decades. Most significant is the Visible Thinking Project at Harvard University (Ritchhart, Church, & Morrison, 2011) aimed at uncovering students' thinking about thinking and providing teachers with strategies to promote the habits of mind that support lifelong learning. The project builds on work by David Perkins and the Cultures of Thinking project that used student-generated concept maps to investigate students' perceptions of thinking—what it is, when they do it, and how to improve it (Ritchhart, Turner, & Hadar, 2009). The findings of this and subsequent research revealed that students who increase their awareness of the strategies and processes they use when thinking become more independent and more effective learners (Ritchhart, Church, & Morrison, 2011). This led to research on how to promote the strategies and processes students could use to build deeper understanding of the material they are learning, which in turn required drawing attention to the mechanisms learners use to construct meaning. This is best accomplished by making thinking more visible during instruction.

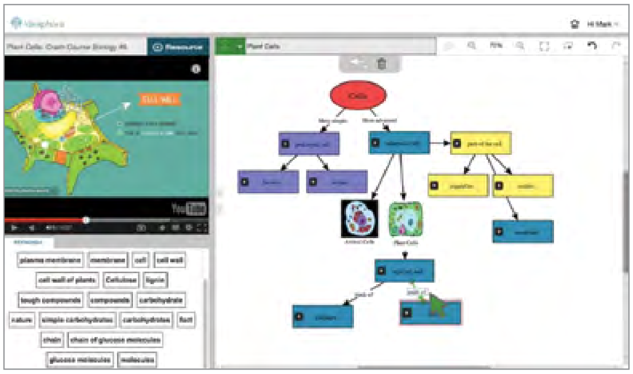
Making thinking visible has a number of benefits for teaching and learning. First, instructional strategies that make thinking visible provide a window into what students understand, as well as insight into their misconceptions. Making thinking visible helps teachers assess the impact of their instruction and correct errors as they occur. Second, strategies for making thinking visible promote student reflection about what they are learning and enable making decisions about how to refine or expand their understanding. Third, by making thinking visible, educators provide students with models for higher-order thinking, strategies for moving beyond thinking as "remembering" toward thinking as "analyzing, evaluating, and creating." One effective approach to making thinking visible is to provide students with ways to visually represent their understanding through drawings, graphs, semantic webs, concept maps, and knowledge maps (Anderson-Inman & Zeitz, 1993; Deschler, 1990; Ritchhart, Turner, & Hadar, 2009; Yongcheng, Scardamalia, et al, 2007). Technology is playing a major role in facilitating the process of making thinking visible by providing digital environments in which student understanding can be made graphically explicit, evaluated, and improved (Anderson-Inman & Horney, 1996/1997; Ditson, Kessler, Anderson-Inman & Maffit, 2001: Tsai, Lin & Yuan, 2001).

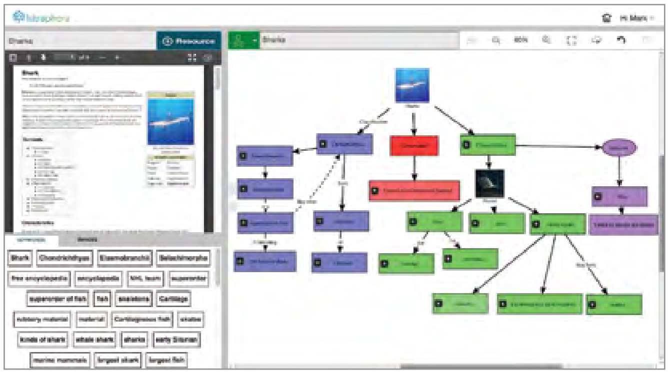
Data Mining and Analytics at Work

Ideaphora integrates data collection and analysis into all phases of its product design, development and improvement process. Some of these data are generated directly by Ideaphora technologies and some through user interaction and feedback.

Identifying and Presenting Key Concepts

The Ideaphora knowledge-mapping environment uses semantic analysis to identify key concepts in the online content made available to students. These key concepts are then presented to learners as "keywords" and "keyphrases" that can be used easily through a drag-and-drop interface to construct knowledge maps.





Identifying Key Concepts

Information contained in speech transcripts of videos, PDF documents, HTML pages, and eBooks are processed to extract textual content and images. Pre-processing includes breaking down the text into sentences and words, and then determining their frequency within the content or across a group of sources with similar content.

The Ideaphora text-mining engine then uses an ensemble of machine learning algorithms to analyze these data. The engine extracts key concepts and relations between key concepts that are considered relevant within the context of the document and the corpus to which it belongs. Weights are assigned to each key concept as part of this analysis.

Refining the Key Concepts

Users are presented with the results of the analysis in the Ideaphora environment. Learners can choose words representing key concepts and place them in their knowledge maps. Learners can then make connections between these concepts to construct and display their knowledge visibly. The knowledge engine examines key concept usage and conceptual connections across sets of maps to improve the weights and other metadata assigned to each key concept.

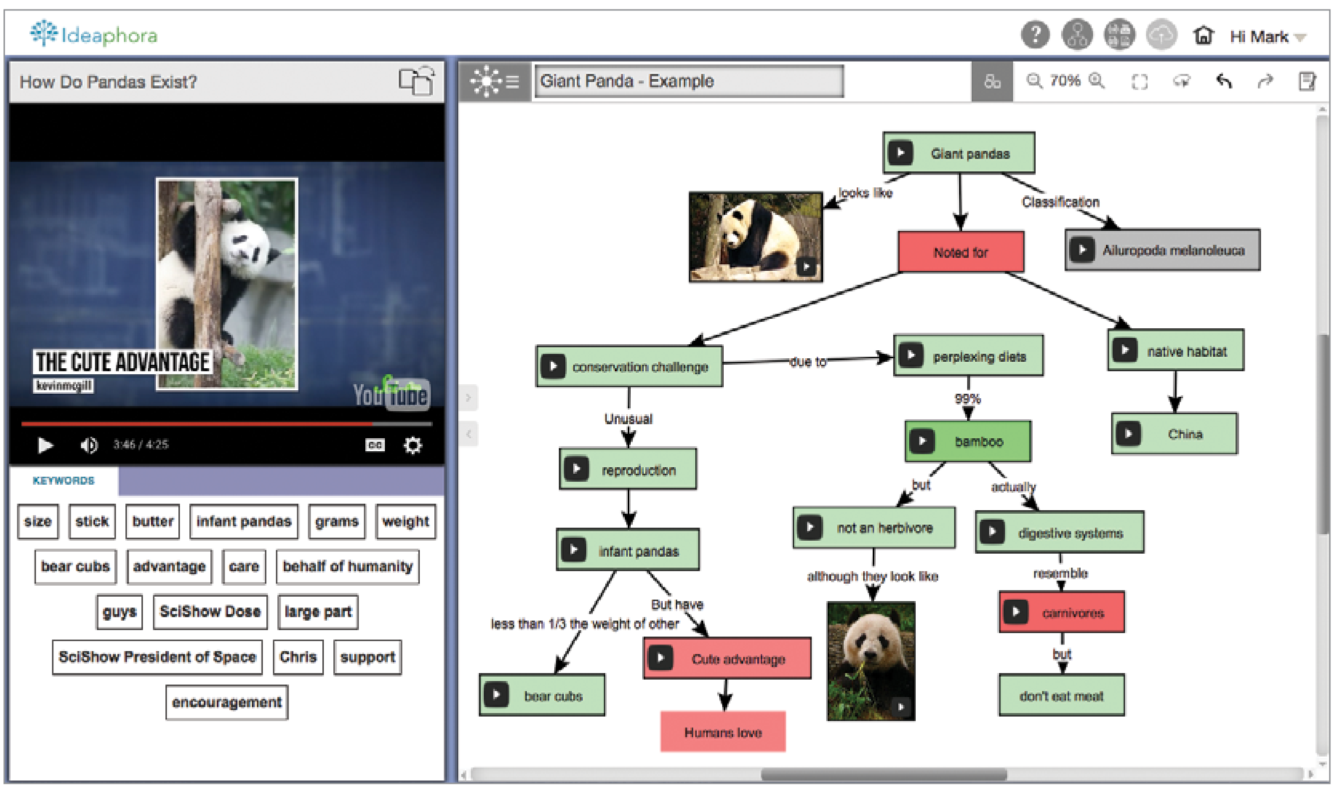
This feedback on how learners interact with key concepts from a given source material is used to improve the relevancy and accuracy of future key concepts and the relationships between them. The refinement process is continuous and documented categorization and keyword weights are constantly updated to ensure that users are presented with the best possible keywords, undistracted by irrelevant or low priority information.

Analyzing User Interface Interaction Patterns

Ideaphora utilizes interaction data to understand how learners are interacting with the user interface to determine its usability and potential impact on learning. For example, Ideaphora has tracked the use of zoom and scrolling features in its user interface. Tracking these features helps to answer questions such as: How often do learners use the zoom feature? How often do learners use the scroll bars? If learners are using the zoom feature frequently, this may suggest that the knowledge map is not usable at normal zoom. If learners spend a lot of time traversing the map using the scroll feature, this may suggest the need for other navigational supports. In both cases Ideaphora decided to improve both these features to allow the learner to add and connect knowledge with less interruption from its interface.

Applying Long-term Knowledge Acquisition Data

Launched in October 2015 Ideaphora's classroom platform contains analytics to discern how and when learners return to their knowledge maps to build and extend their understanding of a topic over time. Ideaphora's technologies examine user interaction data that indicates how students are engaging and interacting with the content and how often they are using previously constructed knowledge to create new knowledge. The analysis of these data can provide students and educators with a long view of how knowledge was acquired and when connections were constructed.



Creating Formative Assessment Opportunities

Maps created in Ideaphora can be submitted to teachers for formative assessment, along with student written explanations of the logic underlying their construction. At present, evaluation requires viewing learners' maps and reading their explanations. In the future, this process will be automated through the intelligent use of Ideaphora's existing analytics. Usage data will be analyzed automatically to improve learning outcomes. The underlying database for this project is already in place and Ideaphora started collecting data from its direct beta users in October 2015. The next step is to define a process for assessing students' maps by comparing them to either an ideal map of the knowledge domain (e.g., one created by an expert) or a crowd-sourced composite of other students' maps.

Classroom Use: BrainPOP® Make-A-Map® Powered by Ideaphora

In the spring of 2014, Ideaphora launched a partnership with BrainPOP® to incorporate concept mapping into their video-based learning platform. BrainPOP's Make-A-Map Powered by Ideaphora features video content paired with the Ideaphora knowledge-mapping environment. Since October 2014, the integrated knowledge-mapping environment has been available to all BrainPOP subscribers, providing access to large amounts of user feedback and early beta and play testers. Working with BrainPOP has enabled the Ideaphora technology to quickly mature and its usability to increase. With its years of experience in providing top quality content and tools, BrainPOP was the perfect partner for Ideaphora to launch its knowledge-mapping environment. The industry leader's focus on first-rate education interactions set a high standard for the Make-A-Map environment.

Make-A-Map has been shown to foster deeper student engagement with BrainPOP content. Students spend 19 minutes on average interacting with the Make-A-Map tool, which is a relatively long time for students to engage with a single learning tool in a classroom setting. Additionally, anecdotal evidence from teachers so far indicates that watching a movie and then using the Make-A-Map tool can increase student performance on quizzes, as compared to watching the movie alone.

Playtest Results

Live playtests with beta versions of the software have helped Ideaphora tailor its environment to make it easier to use, more effective for learning, and fun for students. Ideaphora and BrainPOP, have conducted multiple playtests with students, including teacher and student interviews before, during, and after using our learning environment. From these playtests, BrainPOP and Ideaphora have implemented a variety of interface changes. Examples of its most significant changes based on student and teacher feedback include: making it easier to drag and drop concepts, improving the ease of linking concepts, increasing student ability to personalize their knowledge maps, adding image search capabilities, and making it possible to select and modify multiple concepts at one time.

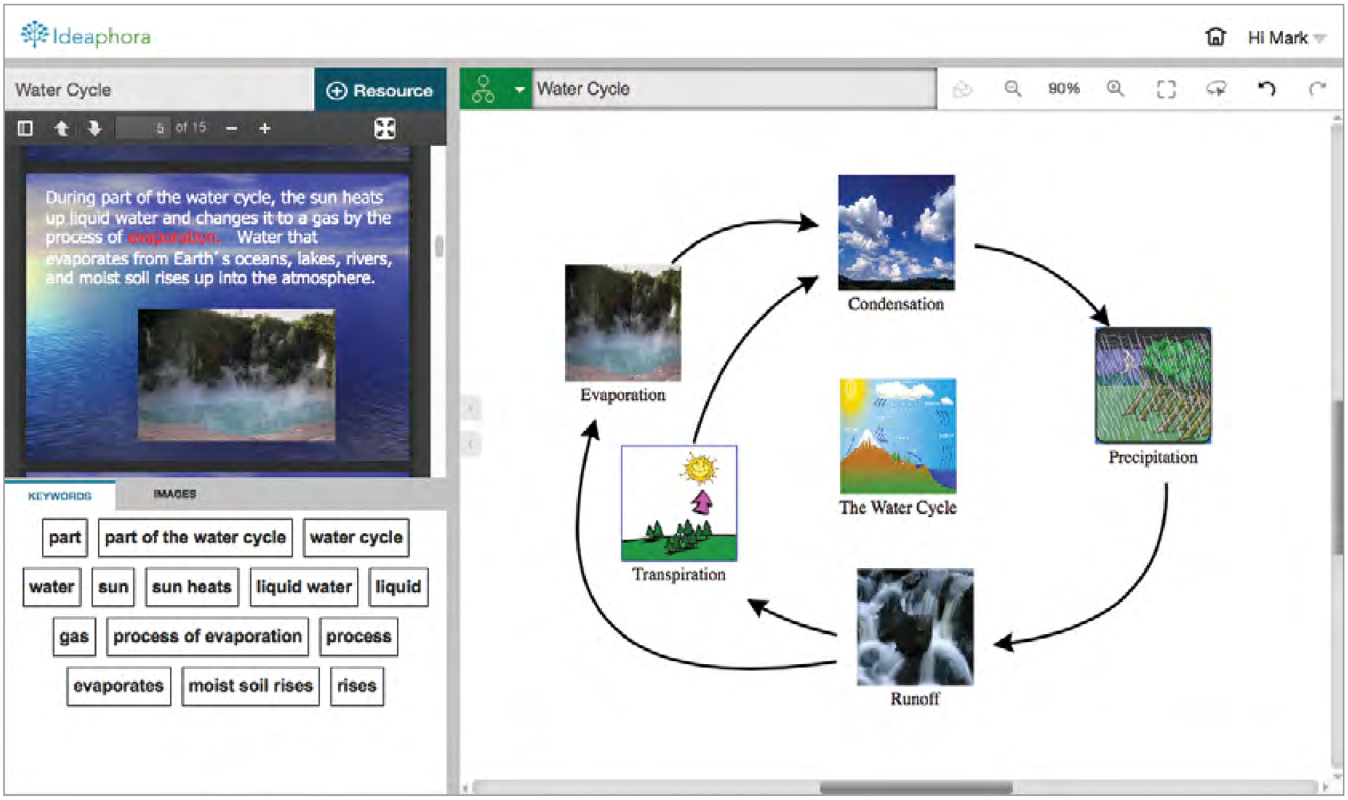
"Whether collecting or demonstrating knowledge, Make-a-Map has deepened my students' understanding across subject areas as evident in their assessments."

—Nili Bartley, Fourth Grade Teacher, Hopkins School, Hopkinton, MA

"My students had so much fun learning with Make-a-Map. They also scored higher on their quizzes after the knowledge mapping exercise, as it encouraged them to think more deeply about the content."

—Lisa Parisi, Fifth Grade Teacher, Denton Avenue School, Long Island, NY

Conclusion



Bringing it all Together for Powerful Learning Experiences

Ideaphora has utilized existing research on the efficacy of digital learning and study techniques to create a theory of how various technologies can be integrated to solve modern learning problems associated with deriving personalized knowledge from digital content. The Ideaphora knowledge-mapping environment was developed informed by multiple evidence-based technologies that are combined for maximum learning potential and ease of use.

User feedback now further informs usability improvements. This is an ongoing process that will continually improve Ideaphora's knowledge-mapping environment for learners of all ages and abilities. Positive feedback from teachers and students show Ideaphora's knowledge-mapping environment is an easy to use and viable way to interact with disparate content sources and promote authentic learning. The result is a sophisticated learning environment built on well-established research and real world experience that can help solve educational challenges today and in the future as schools increasingly transition to digital content.

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Ideaphora

2748 Vale Court

Lake Oswego, OR 97034

US & Canada Toll Free 1-800-324-9612

International +1 503-894-7983

info@ideaphora.com

www.ideaphora.com