

Asia-Pacific Forum on Science Learning and Teaching, Volume 11, Issue 2

FOREWORD

Designing Science Instruction using the Web-based Inquiry Science Environment (WISE)

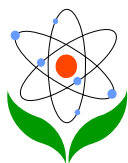
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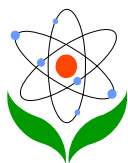
Abstract

The Web-based Inquiry Science Environment (WISE) supports research on student learning and design of curriculum materials. An international community of researchers, teachers, designers, and technologists contribute to the ongoing success of WISE. The community has helped shape the knowledge integration framework that synthesizes findings in design patterns and principles. Over 5000 K-12 science teachers and more than 250,000 students take advantage of the WISE curriculum materials annually. WISE materials are free, available in 7 different languages, and used in numerous countries around the world. Research teams regularly contribute new insights about online learning, improved curriculum materials, and innovative ways to support teachers using WISE units.

Each WISE inquiry unit is organized around a personally-relevant question such as, *What can I do to reduce greenhouse gas emissions?* WISE curriculum materials and assessments feature powerful, interactive scientific visualizations to illustrate unobservable phenomena such as chemical reactions at the atomic level, large-scale phenomena such as climate change, and phenomena that happen quickly such as collisions. The online environment logs student interactions and responses to embedded assessments. WISE offers teachers grading and classroom management tools to monitor student progress, provide feedback to students, and personalize instruction.

This year, WISE released a new, open source environment that makes it easy for teachers, researchers, and developers to adopt the WISE technology, learning tools, and curriculum materials. WISE is establishing an international open source community including researchers and developers who extend WISE and apply it in their local contexts. This paper reviews WISE research, describes the new version of WISE technologies, and introduces opportunities for educators around the world to participate.

Keywords: online, open source, learning, teaching, visualizations, assessment, science, inquiry.



Introduction

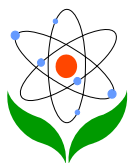
The Web-based Inquiry Science Environment (WISE) has been supporting research on inquiry-oriented science on the Web for nearly 15 years. Throughout this time, we have offered WISE free-of-charge to the community. Many researchers and curriculum designers have added projects and features to WISE.

A wide audience of K-12 science teachers use existing WISE curriculum projects. Currently, there are over 250,000 student accounts with approximately 3000 new student accounts being added each month. Each year, about 5000 teachers use WISE (around 400 each month). Each year many teachers and researchers actively author new WISE units specific to their state standards and contexts.

Over the years, the WISE user interface has been translated into 7 different languages, and employed in thousands of schools. This year, we celebrate the release of our newest version of the WISE technology, which has been configured as a modular open source project that should make it easy for developers to adopt and adapt the WISE technology, learning tools, and curriculum materials. Below, we review the research foundation, then describe our new version of WISE technologies, and introduce opportunities for educators around the world to participate.

WISE curriculum and assessments feature powerful, interactive scientific visualizations to illustrate unobservable phenomena such as chemical reactions at the atomic level, large-scale phenomena such as climate change, and phenomena that happen quickly such as collisions. Each inquiry project is organized around a personally-relevant question such as, “What can I do to reduce greenhouse gas emissions?” The WISE units are designed using the knowledge integration framework (Linn & Eylon, in press; Slotta & Linn, 2009). The environment captures student interactions in embedded assessments and offers teachers grading and classroom management tools to provide feedback to students, track student trajectories, and monitor student progress.

In this paper we describe the knowledge integration framework that we use to align instruction, curriculum, and assessment. We discuss the curriculum design process and summarize some recent research. We describe the latest version of WISE as well as the resources available to everyone free-of-charge.

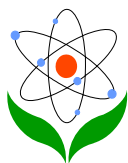


Background

The WISE software, curriculum, and teaching approaches are based on more than twenty-five years of research on learning with technology. Early research investigated the use of simulations and probeware to help students understand science topics more deeply (e.g., Songer & Linn, 1991; Linn, 1995). This work produced the first version of the Knowledge Integration Framework. The framework emerged from longitudinal study of students learning thermodynamics. It describes the complex repertoire of ideas students bring to science class and stresses the importance of building on student ideas and using personally relevant contexts to make science accessible. The framework emphasizes the benefits of using powerful technologies to make thinking visible and the importance of encouraging students to learn from each other. The framework called for using technology to encourage carefully designed reflections that could foster a lifelong habit of autonomous learning (see Linn & Hsi, 2000).

With the arrival of the World Wide Web, we developed new technology environments such as KIE – the Knowledge Integration Environment that offered powerful inquiry projects and made use of the wealth of resources from the Web (Bell, Davis & Linn, 1995). This research explored ways to take advantage of online learning. One group investigated effective designs for reflection prompts (Davis & Linn, 2000). Another group explored the use of technology scaffolds for argumentation (Bell, 2004). Some researchers studied the role of social information in helping students develop scientific arguments (Hoadley & Linn, 2000). Others explored effective designs for online discussions (Hsi & Hoadley, 1997). Another group explored the role of advance organizers and cognitive hints to support effective use of Web resources (Slotta and Linn, 2000). A group led by former teachers researched effective teaching practices for inquiry with technology as well as effective professional development approaches (Slotta, 2004; Williams, Linn, Ammon & Gearhart, 2004).

This research informed the design of WISE, including the overall technology environment, the specific learning tools (e.g., drawing tools, concept maps, online discussion forums, etc), and the design of all curriculum and assessments.



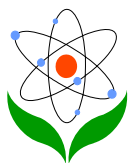
The Knowledge Integration Framework: Guiding the design of WISE Curriculum and Assessments

The knowledge integration framework describes the learner as holding a repertoire of ideas, rather than a single account of most any scientific phenomena, consistent with extensive research in the field (Case, 1985; diSessa, 2000; Howe, Tolmie, Duchak-Tanner, Rattray, 2000; Metz, 2000; Siegler, 1995; Sisk-Hilton, 2009). The framework describes how instruction can take advantage of the repertoire of ideas held by individuals, and by the group of learners in the classroom (Eylon & Linn, in press; Linn, 2006). The framework describes four processes that jointly lead to knowledge integration. The processes enable students to sort out their repertoire of ideas to form a more coherent understanding of science. Designers and teachers use the pattern to inform creation and customization of curricular activities. The four processes are:

Elicit ideas. Knowledge integration emphasizes eliciting and building on student ideas. Research shows that students develop a repertoire of ideas about scientific phenomena that reflect their observations, experiences, and intellectual efforts. Many studies show the benefit of eliciting ideas or making predictions (e.g., Gunstone & Champagne, 1990). By articulating their ideas students are prepared to test them against new ideas.

Add ideas. Adding new ideas is the goal of every science activity. Technologies can make unique ideas visible (Linn, Lee, Tinker, Husic, & Chiu, 2006). Interactive visualizations illustrate phenomena that are too small (chemical reactions), fast (collisions), or massive (the solar system) to explore in the classroom. Virtual experiments can allow students to investigate situations that are complex (global climate change), dangerous (airbag deployment), or prolonged (genetic inheritance). In knowledge integration activities, new ideas are introduced using interactive experiments, visualizations, and other activities that allow learners to explore the relationships among all their ideas.

When new ideas meet the criteria of *pivotal cases* they are effective for promoting knowledge integration (Linn, 2005). Pivotal cases typically *contrast two conditions* that form a controlled experiment. For example, to help students interpret their idea *that metals are naturally cold*, developed from numerous observations that metal objects feel colder to the touch than wooden objects when at room temperature, Mr. K, a collaborating teacher asked students to contrast how metal and wood feel on a

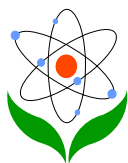


hot day at the beach and a cold day in the snow. In addition, pivotal cases are *personally relevant* and *elicit a narrative*. For example, when contrasting wood and metal on hot and cold days, the many students immediately start describing their own experiences getting into a hot car, walking on wooden or metal ramps, or freezing their fingers to a car door. Finally, pivotal cases *emphasize the language and methods of science*. For example, to make the metal and wood case effective, students are encouraged to contrast how objects feel on hot and cold days with their temperatures as measured using a thermometer. Instructors model the process of distinguishing heat flow from temperature using scientifically normative language. WISE designers seek pivotal cases so that new ideas are generative and productive.

Distinguish ideas. Students require carefully designed, supportive instruction to help them consider new ideas and distinguish productive ideas from unproductive ones. Students are prone to add new ideas and use them in the context where they were learned (school) but to ignore them under other circumstances (Linn & Hsi, 2000). Visualization can be *deceptively clear*: students may believe they understand a visualization without considering the details (Chiu & Linn, in press). WISE can guide students to distinguish among ideas by, for example, making drawings of their observations, conducting experiments to compare alternative explanations, or critiquing interpretations of visualizations.

Sort out ideas. Students need opportunities to try out their new ideas, reflect on the alternatives, and reorganize the connections among their ideas. WISE can guide students to organize their ideas in a narrative, explain their ideas to a peer, write a persuasive argument to a government official, or make a visual representation of their knowledge. These activities help students prioritize their ideas and identify the most coherent and generative views. Ultimately students need to coordinate productive ideas, prior knowledge, and experience to achieve coherent and durable scientific understanding.

Together these processes comprise the knowledge integration pattern (see Figure 4). The pattern can be used to design, review, or critique curriculum materials. It can offer new directions for refining an activity. WISE supports authors desiring to use the knowledge integration principles and pattern to design curricula that promote coherent scientific understanding and to design assessments to measure student ability to integrate their ideas.



A complete summary of WISE research, theoretical framework, technology and curriculum features is provided in a recent book by Slotta & Linn (2009). In addition Kali, Linn, & Roseman (2008) summarized the similarities and differences between the knowledge integration framework as reflected in the research by the Technology-Enhanced Learning in Science (TELS) center (see <http://telscenter.org>) and the curriculum framework employed by the Center for Curriculum Materials in Science (CCMS).

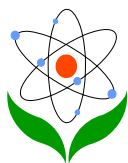
Research Findings

An extensive set of research findings supports the use of the WISE curriculum materials. Each WISE project in the curriculum library has been iteratively refined in classroom trials. These studies investigated the effectiveness of the overall design as well as specific features. The investigations improved the units and also provided insights that informed the knowledge integration framework.

Investigating Mitosis and Meiosis

Elisa Stone investigated the mitosis and meiosis activities for middle and high school. Understanding concepts of cell division and growth is a fundamental topic in biology. When high school students and teachers were asked what concepts in cell biology are particularly challenging, they identified the processes of cell division- mitosis and meiosis- to be among the most difficult topics to learn.

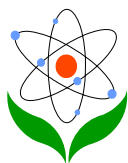
In response, the WISE “*Investigating Mitosis and Meiosis*,” was designed and piloted in a 10th grade biology classroom. This WISE unit guides high school students to explore web-based animations and cell images, build and analyze their own models, make connections to excellent web resources on cell division, and undertake an internet research project on related human diseases. The goals of this research were to (1) learn more about how students understand concepts of the cell, (2) evaluate the WISE cell division curriculum, and (3) determine how the unit could be revised to improve cell biology instruction. To determine the extent to which students developed a coherent understanding of meiosis and mitosis, knowledge integration scoring rubrics were developed and student work from several different assessments was analyzed. Embedded assessments, student models, pre/post test drawings, multiple choice exam questions, and student reflections were examined.



Different ways that students constructed their understanding of cell division, and a variety of challenges they encountered while learning about cell division in the WISE project, were revealed by evaluating student work from different methods of assessment. For example, analysis of students' reflection notes, captured as part of the WISE curriculum design, revealed that interpretive questions revealed more about what students had learned than descriptive ones. Analysis of drawings and models suggested that students did not fully understand mitotic spindle function, and revealed a need for more emphasis on this component of cell division. Throughout this evaluation, it was noted that students who did not perform well on some assessments might unexpectedly perform well on another. For instance, several students did not respond fully or accurately in writing but made creative, thoughtful models using the WISE drawing tool. Thus, not only are multiple methods of assessment beneficial for teachers, but they can also be beneficial for students in allowing them to demonstrate their understanding in different ways. These conclusions are consistent with the research literature on alternative approaches to assessment. Using a variety of alternate approaches to assessment benefits learners by giving them varied ways to succeed. In addition, when used as formative assessment, varied outcome measures help teachers improve their practice by providing a nuanced image of student learning.

The first classroom trial of this WISE project showed that the curriculum met its learning goals. Throughout the WISE curriculum unit, students increasingly integrated their understanding of the process of cell division, the events that characterize mitosis and meiosis, the function of cell structures important for cell division, and to modeling of defects that occur in related diseases. A number of revisions were made for the next iteration of this curricular unit that aimed to improve the curriculum and increase the number of students that reach fully integrated understanding of cell division. The revised WISE unit, called "*Cell Reproduction & Human Diseases*" was taught the next year in a 10th grade biology class and customized for a 12th grade biotechnology class.

The second year of research focused on how students used models to represent their ideas about cell division and cancer. Models were analyzed at three points in the curriculum unit (early, middle and late) with rubrics that determined students' conceptual understanding of the structure and function of cellular components required for cell division, and their ability to reason about causes of diseases. Knowledge integration rubrics were used to measure student models. They were



particularly useful for evaluating student drawings by offering an objective way to discern evidence of learning. Data obtained from scoring with these rubrics showed that students progressively integrated their knowledge of cell division from the beginning to the end of the unit. Moreover, students developed a greater understanding of the nature of science by learning to evaluate their own models and to appreciate the purpose of models in general. This study demonstrated that adaptations to the curriculum after its first year resulted in increased learning gains in the second year of its implementation. Additionally, analysis of student data demonstrated areas where students continue to have difficulty in conceptual understanding. These analyses suggested changes in the curriculum for a third year of implementation.

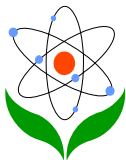
In sum, evidence for the progression of student ideas about cell division was seen in multiple ways. Student explanations of cell division metaphors, cellular models of disease, and drawings of the process of cell division were especially effective in understanding students' ideas about mitosis and meiosis. Using different kinds of assessment throughout the WISE unit revealed which elements of the curriculum were successful in promoting student learning in cell biology.

Investigating Genetic inheritance

Jacquie Madhok explored how students learn in the WISE “*genetic inheritance*” project. She reports on two research questions:

1. How does the TELS *Simple Inheritance* project contribute to student knowledge integration compared to a typical curriculum?
2. How effective is the project for high and low performing pretest students, i.e., do both students who score low and students who score high on measures of genetic inheritance at the pretest show progress in their understanding of genetics by the posttest?

While using this unit, students explore the content within a personally relevant context (see Figure 1). Students assume the role of a school newspaper reporter and are guided by the project’s “Managing Editor” to investigate the fictional case of a boy who has cystic fibrosis. Students collect evidence on cystic fibrosis to be used for writing an article about this boy (named “Eric”) in their school newspaper.



Eric's Case File: Medical Background

Case File

Eric's accomplishment gave his lungs an overwhelming challenge. Remember, Eric is living with a disease called **cystic fibrosis (CF)**.

THE SYMPTOMS OF CYSTIC FIBROSIS (CF)

- CF is a progressive and frequently fatal disease of the body's mucous and sweat glands.
- CF directly affects Eric's respiratory and digestive systems.
- Sweat is responsible for cooling the body. Eric produces too much sweat and loses excessive amounts of salt. This can cause abnormal heart rhythms.
- He also produces too much mucous. Mucous lubricates body organs, like the lungs and intestines. It prevents tissues from drying out and protects them from infection. Because mucous is very thick, it accumulates in Eric's intestines and lungs.

Figure 1: Students learn about Eric who has cystic fibrosis, his symptoms

Students then use interactive, dynamic visualizations to develop family trees with online tools (see Figure 2), explore phenotypic outcomes of gene combinations, and change parents' genotypes to see samples of genotypes for children.

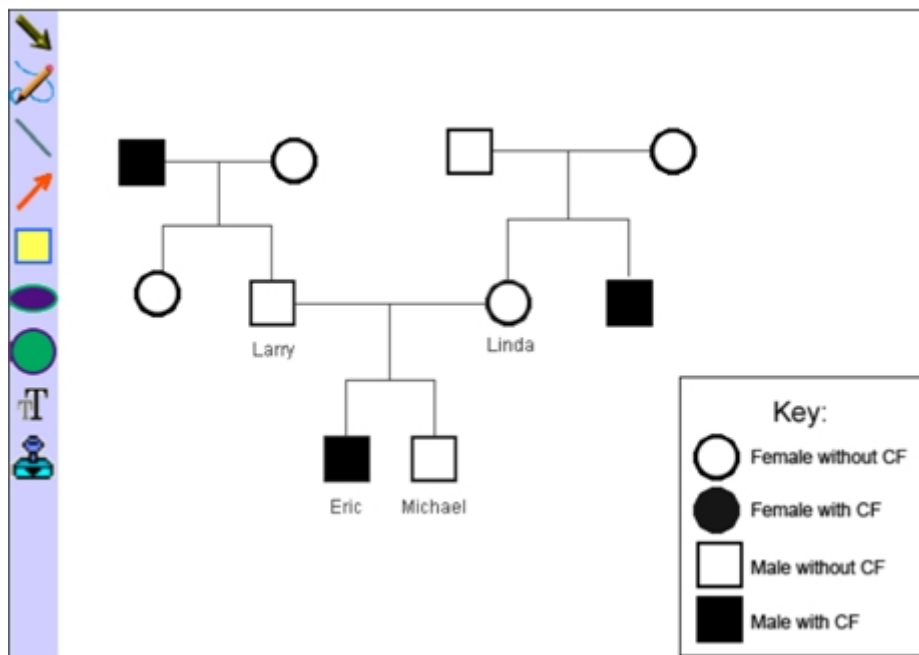
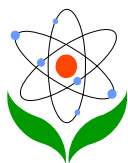


Figure 2: Students use embedded drawing tools to create Eric's family tree.



To measure the impact of this week-long WISE curriculum unit, pre- and posttests were given to the students, and a delayed posttest was given 6 months later. Figure 3, below, shows some sample assessment items.

Question 1a. *Some students can curl their tongues while others can't. You observe that a mother and a father can curl their tongues, but their child cannot which of these traits is the dominant trait? (Choose one)*

_____ *Tongue-curling Ability* _____ *No Tongue-curling Ability*

Explain your choice.

Question 1b. *What is the probability that these parents will have a child that will have the tongue-curling ability? Explain how you got your answer.*

Explain why or why not.

Figure 3. *Sample assessment questions for genetic inheritance.*

To answer the question “How does the *Simple Inheritance* module contribute to knowledge integration, compared with a typical curriculum?”, comparisons were made between students for one teacher, Lisa, who employed the WISE curriculum in year 1 and year 2 and the typical curriculum in year 4. The 300 students who had used WISE were compared with the 113 students who had experienced the typical curriculum. There was a significant difference in the yearly benchmark test scores across these two groups, with $F(1, 639) = 26.05, p < .0001$. Specifically, the students who used WISE achieved much higher scores on the inheritance measures than the students who had studied without the WISE module (see Figure 4).

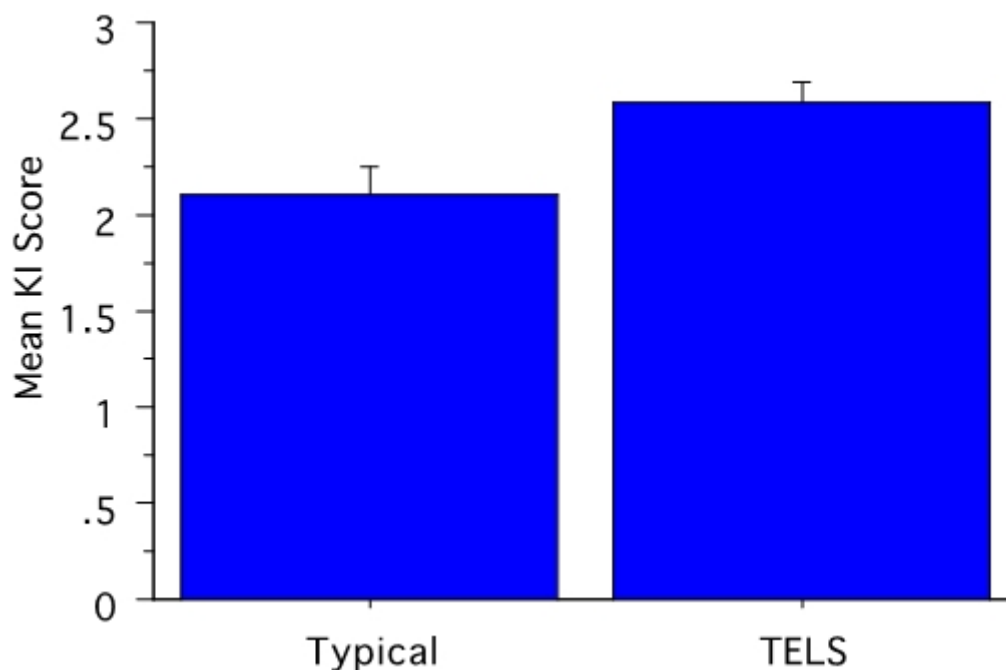
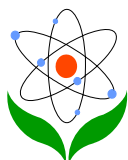


Figure 4. *Students who studied with the module (TELS [$n = 300$]) significantly outperformed those students who studied without the module (Typical [$n = 113$])*

To answer the second question, “How effective is the module for high and low performing pretest students?” progress in the understanding of inheritance at pre- and post-module were analyzed using test results from three teachers. The Simple Inheritance module resulted in significant gains in measures of the students’ understanding of inheritance for both students’ with low pretest scores, $F(1, 78) = 100.61$, $p < .0001$ and the students’ with high pretest scores, $F(1, 60) = 46.74$, $p < .0001$ (see Figure 5).

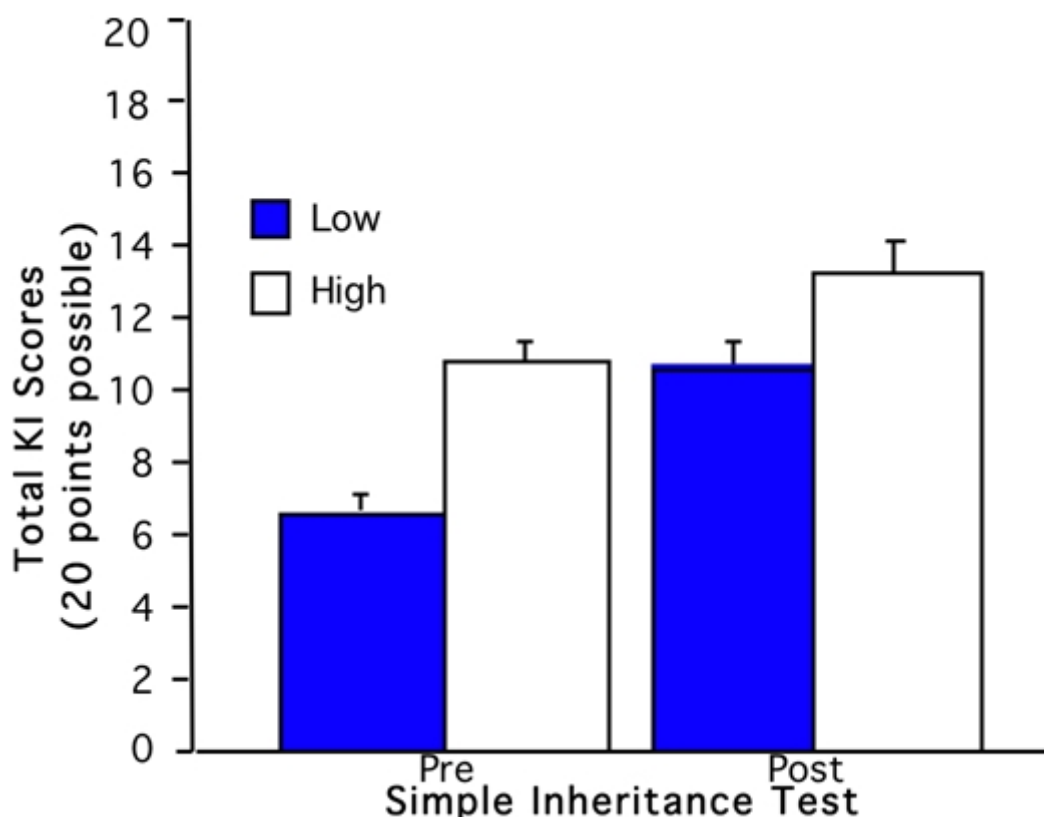
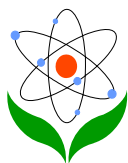
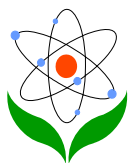


Figure 5. Both students who scored low on the pretest [$n = 79$] and those who scored high on the pretest [$n = 61$] made significant gains from pretest to posttest.

In summary, the combination of visualizations, reflection, and connections to a personally relevant story help to make WISE curriculum units effective. Wider use of such research-based units in classrooms has strong implications for improving science education results.

Promoting an Open Source Community of Research and Development

From the outset, we have attempted to make WISE technology and materials available to the wider audience of researchers and educators around the world. WISE is open source and useful for researchers and developers. Users can author and customize units using an accessible set of authoring tools, and hundreds of interesting curriculum projects have been created for WISE, many of them adaptations of our research-based materials. Software designers have contributed new capabilities to WISE, adapting their own powerful learning tools into Java Applet forms, to run within Web pages for WISE projects, or even fully integrating



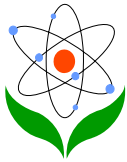
their tools into the WISE architecture. Teachers and professional developers have customize curriculum units based on evidence from student work. Researchers have used WISE curriculum and assessments (which are aligned with the curriculum unit) to test alternative educational treatments.

WISE has a long tradition of supporting open exchange of technology and resources. The technology itself has undergone several major revisions, in order to achieve a higher level of modularity and accessibility to an open source community. A great deal of this work has focused on developing the Scalable Architecture for Interactive Learning (SAIL) which can be used in turn to develop a wide range of technology environments (Slotta and Aleahmad, 2009). Recently, we have produced the 4th major release of our software, which features a new portal and user registration system, an improved “Virtual Learning Environment” (VLE), a structured content model (similar to xml) and new functionality for interoperability with other platforms and learning tools. In the next section, we review the basic elements of this technology.

Introducing WISE Version 4

WISE4 is committed to providing the best open source solution to inquiry-based learning. It is built using proven open source frameworks and tools such as Spring Web Framework, Acegi Security, Hibernate, and jQuery. These tools are each backed by a strong group of specialized developers and users and provide a stable and reliable development environment for WISE. Using these technologies, WISE has developed a user and course management system (the WISE portal) and a Virtual Learning Environment system (the WISE VLE), both of which are offered under an open source, license. The two technologies can be used independently, but have been developed to work smoothly together, and can be downloaded from the WISE software project page: <http://code.google.com/p/wise4/>.

The WISE portal is a server-side Java web application that coordinates user sessions, permissions, user data and content storage and delivery (see Figure 6). It is an open-source project that was created by contributors from across 4 different institutions in over 3 years. It is currently being used in (and consequently, supported by) 3 major software initiatives, including WISE 4. The portal features a separated language tree, allowing it to be presented in most languages, and its design and behavior can be customized to fit the specific needs of a wide range of applications. It supports most recent browsers, and works best with Firefox.



Currently, work is in progress to translate the portal text into additional languages and improving compatibility with more browsers.

WISE 4.0 BETA
the web-based inquiry science environment

Welcome to WISE

WHAT IS WISE?
CURRICULUM BASED
INQUIRY PROJECTS
STUDENT ENGAGEMENT
INTERACTIVE MODELS
TEACHER TOOLS
FREE & OPEN SOURCE

Click above for details

What is WISE?
The Web-based Inquiry Science Environment is a research-based digital learning platform that fosters exploration and science inquiry. Students observe, analyze, experiment, and reflect as they navigate WISE projects. Teachers guide and evaluate the process using a suite of classroom-based and online tools. This site hosts the latest and most powerful version of WISE – version 4.0. Classic WISE can be accessed at <http://wise.berkeley.edu>.

Create WISE Account
Preview a Project
Animated Overview
Contact WISE
Check Compatibility

Sign In
Username:
Password:
SIGN IN
Forgot your Username or Password?
[Create a new WISE account](#)

New To WISE?
Teachers, please take a look at our [Getting Started Guide](#) to find out how to use WISE in your classroom.

WISE in Action
Interactive simulations let students form hypotheses and test them across multiple trials.

Testimonials
Priscilla Robinson
Biology Educator
Martinez Junior High, CA
"As a teacher, there is nothing better than seeing and feeling the excitement of a student's discovery process ignited. Utilizing this technology has helped me to grow as a teacher."

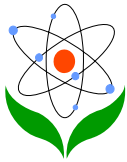
WISE News
WISE4 Now Available
We are pleased to announce that our new learning environment WISE4 is now available in open beta format. WISE4 does require creating a new account. There continues to be no cost or commitment to joining. We will be continuing to add new projects over the next few months. Let us know what you think.

News Archive

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Supported by the National Science Foundation, TELS Grant No. 0334199.
Powered by WISE 4.0 open-source technology. Optimized for Firefox browser.
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Figure 6. WISE Portal Homepage

The WISE Virtual Learning Environment (VLE) is a client-side technology written with HTML, Javascript, and CSS (see Figure 7). The VLE handles loading, rendering, and saving of curriculum content and learner data. These main functions are “componentized” so that any individual component can be replaced by an alternative component with different behavior or view. In other words, if researchers or developers need to use one of their own pre-existing components, they can replace the default ones that are provided with WISE . Various initial parameters can be passed to the VLE, such as session data, location of the curriculum, and visual theme and language of the VLE interface. Like the portal,

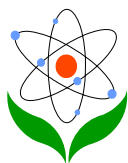


individuals can customize both the visual layout and the language of the VLE.

The screenshot shows the WISE 4.0 BETA interface for the 'Plate Tectonics' project. The main content area displays a diagram titled 'Which Way Are Plates Moving?' showing a cross-section of the Earth's crust and mantle. The diagram illustrates a continental plate moving towards a mountain range, with arrows indicating the direction of movement. Labels include 'Mountain', 'Continental Crust', 'Mantle', and 'Continental Plate'. A control panel at the top right of the diagram allows users to select different plate boundary types: 'Convergent' (Continental-Oceanic, Continental-Continental, Oceanic-Oceanic), 'Divergent' (Continental-Continental, Oceanic-Oceanic), and 'Transform' (Continental-Continental, Oceanic-Oceanic). A 'NEXT' button is located at the bottom right of the diagram. The left sidebar shows a navigation menu with various steps, including 'Initial Ideas', 'What's Our Country Like?', 'What's Happening Outside?', and 'What's Going On Inside?'.

Figure 7. *The WISE VLE running the “Plate Tectonics” Project*

Institutions that have developed their own online educational tool can take advantage of WISE4’s plug-in architecture to embed the tool as a WISE step type. Developers can reference the online documentation at the following URL: <http://code.google.com/p/wise4/wiki/HowToCreateANewWise4Step>. Making a tool into a WISE4 step plug-in allows WISE to deliver the tool as an integral part of the WISE project, instead of as a stand-alone application. This means that WISE will handle user and data management, reporting, and deployment, thus freeing up the developer to focus on improving the functionality of the tool. WISE offers a default suite of “core step types,” including reflection notes, open response items, evidence pages, drawing tools, concept maps, and other assessments formats such as multiple-choice and fill-in-the-blank items. Some of these step types were written by developers outside of the core development team and folded into WISE using the plug-in method.



The WISE content model is loosely based on the IMS Learning Design (IMS/LD). The data files for a sample curriculum project called Plate Tectonics can be downloaded from the project website (see `platetectonics.zip` on this page: <http://code.google.com/p/wise4/downloads/list>). The content for each step (or “node”) in the project is stored in its own separate file. A main “project file” stores references to all of the nodes within the project and how they should be sequenced and displayed. The project is stored as a JavaScript Object Notation (JSON), similar to a .xml representation, and can be stored in its entirety in a folder, as seen in the sample project (i.e., without external resources that are referenced from within the project). This allows for easy compression, parsing, versioning, and transferring of the project.

Extending WISE to the International Community

WISE has been designed to support international partners in creating language translations of both the curriculum and the user interface. Authoring WISE curriculum in a language other than English requires no additional effort on the part of the author, as any language can be entered into the WISE authoring tool. The WISE portal will be developed in several different languages in the near future. As of this writing, WISE is being installed or has already been used for research in at least 5 different institutions outside of Berkeley: University of Washington, University of Virginia, Rutgers University, South China Normal University, and National Kaohsiung Normal University (in Taiwan). Some of these research groups have progressed quickly to using WISE in classroom trials, and others are still refining their tools for upcoming efforts. Our partners in China and Taiwan are currently engaged in translation efforts.

WISE in Taiwan

In Taiwan, students, teachers, and researchers have collaborated to create WISE materials by customizing US materials. Chang and her colleagues have designed and studied for projects (see Figures 8-12)

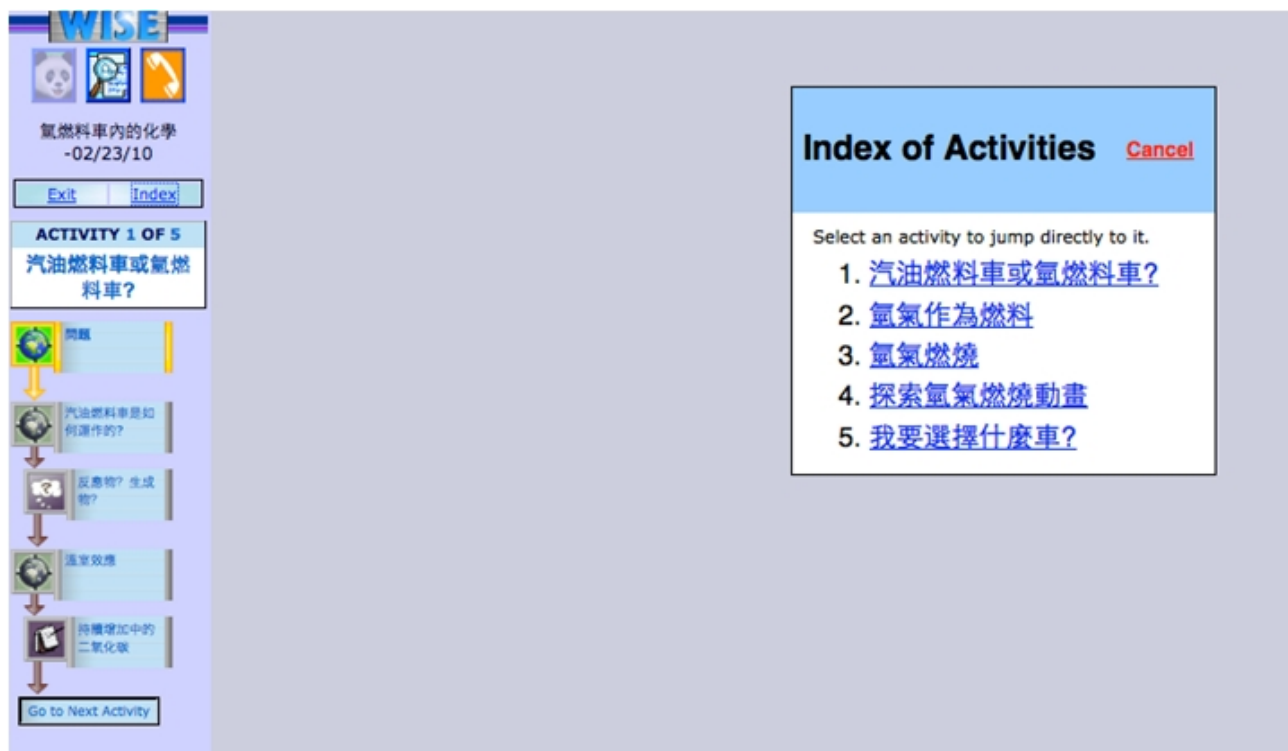
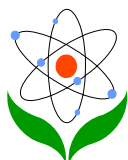


Figure 8. WISE interface for Hydrogen Fuel Cell Cars in Taiwan.

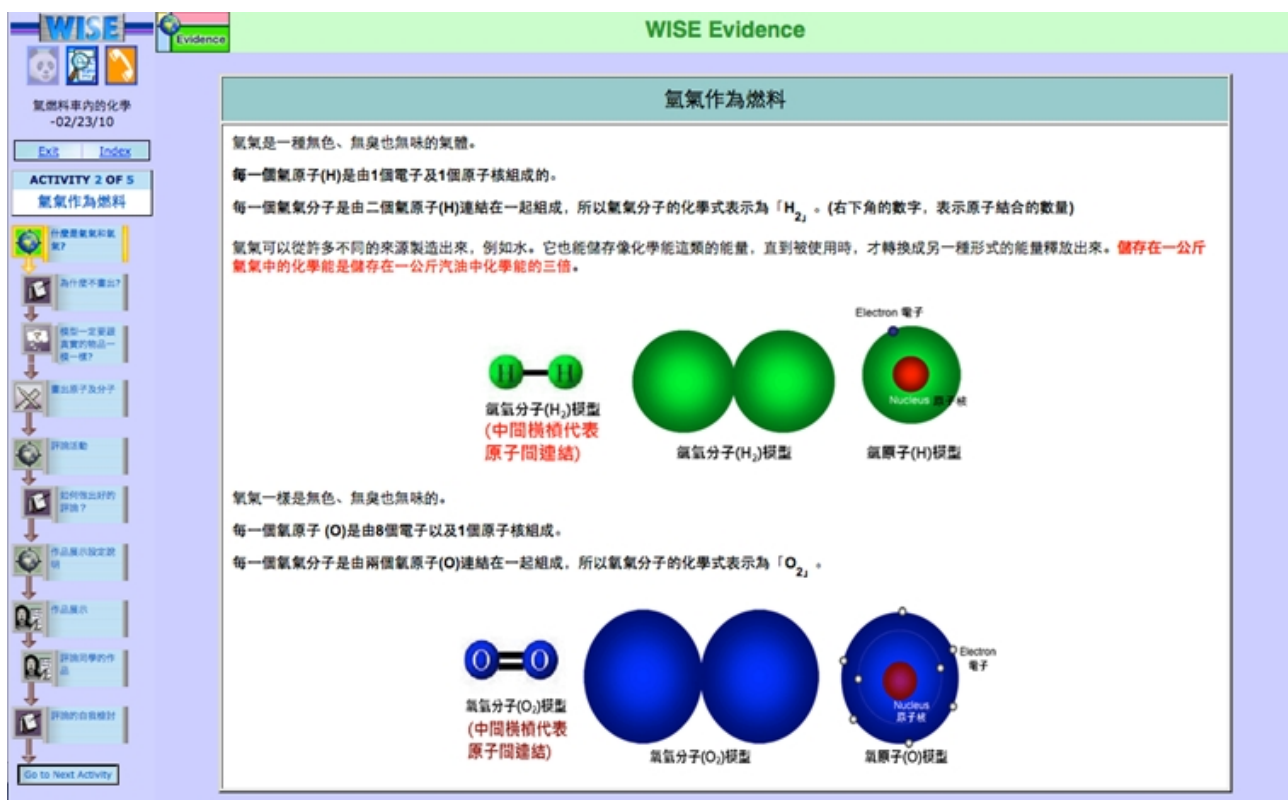
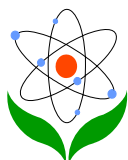


Figure 9. Curriculum Activity in WISE Hydrogen Fuel Cell Cars

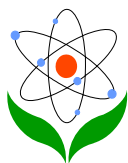


The screenshot shows the WISE interface for a chemistry activity. The title is "泰瑞畫的圖". Below the title, there is a chemical equation: $6\text{H}_2 + 3\text{O}_2 \rightarrow 6\text{H}_2\text{O}$. The instructions are in Chinese and describe a drawing task. The task involves four steps: Step 1: Drawing the distribution of molecules before the reaction starts. Step 2: Drawing the distribution of molecules at the start of the reaction. Step 3: Drawing the distribution of molecules during the reaction. Step 4: Drawing the distribution of molecules after the reaction is complete. Below the instructions, there are four diagrams illustrating the reaction process. Diagram 1 shows 6 H₂ and 3 O₂ molecules. Diagram 2 shows a spark (represented by a flame) and the beginning of bond breaking and forming. Diagram 3 shows the atoms moving and bonds breaking. Diagram 4 shows the final products, 6 H₂O molecules.

Figure 12. An assessment activity in Hydrogen Fuel Cell Cars

Implementing WISE

To set up an instance of WISE, a user with basic knowledge of Web server administration can simply visit the WISE software project page and follow the instructions for downloading and installing the project: <http://code.google.com/p/wise4/wiki/StableWISEDeploymentModel>. The documentation of all WISE software continues to be improved, and currently reflects the most up-to-date information and released software. WISE4-dev (<http://groups.google.com/group/wise4-dev>) is a group of WISE developers and server administrators that help each other through the WISE installation and maintenance processes. It is recommended that the server administrator join this group before he or she begins the installation process.



Conclusions

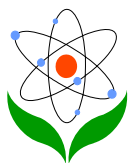
In summary, the new WISE4 technology makes it easy for educators at other institutions to adopt, customize and use WISE for their own research or educational programs. The plug-in architecture allows existing software to easily integrate with WISE. Curriculum materials that were authored at one institution can be easily moved to a WISE instance running at another institution. In the future, the plug-in tools can be shared with the wider community of WISE users and developers, similar to browser extensions. Sharing software code and curriculum content across multiple institutions will allow researchers to scale and share their research in new ways.

WISE4 offers teachers and researchers proven science inquiry curriculum units for middle school and high school students. To create a WISE4 account, go to <http://wise4.telscenter.org/> where you will find WISE very easy to use and access examples and support materials. There is no commitment required for joining WISE. We will be continuing to add new curriculum units over the next year, as we move them from the previous version of WISE (still located, for the present time, at <http://wise.berkeley.edu>). WISE is funded by the U.S. National Science Foundation.

For more information contact either: Marcia Linn (mclinn@berkeley.edu) or Jim Slotta (jslotta@oise.utoronto.ca).

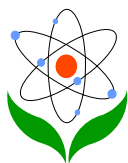
Acknowledgements:

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