

## Project Profile

### **Project title: Web-based Inquiry Science Environment (WISE)**

#### **1. Abstract**

Please provide a short (200 word) description of the curriculum. Feel free to reuse existing descriptive text if possible.

The Web-based Inquiry Science Environment (WISE) is a free on-line science learning environment for students in grades 4-12, supported by the National Science Foundation. WISE is designed to support researcher- and teacher-designed online investigation projects that typically run from two days to two weeks.

Researchers at Berkeley have designed a suite of water quality-related WISE projects. These projects center around the goal of learning about a local watershed, with a central question that explores “who can drink the water” — is the water safe for a range of possible uses. The projects are targeted for middle school and high school science classes, and last between one and two weeks.

The projects are intended to be customized to allow students to explore a local watershed and make sense of the environmental factors that contribute to water quality. The project is often combined with a field trip to the stream site to gather data and take observations of the watershed.

A short online introduction to WISE can be found at:  
<<http://wise.berkeley.edu/pages/intro/wiseIntro01.html>>.

If you have a WISE account (they’re free; visit [wise.berkeley.edu](http://wise.berkeley.edu) to create one), you can preview the middle school project, Pine Creek, by following this URL:  
<<http://wise.berkeley.edu/student/startProject.php?projectID=2990>>.

#### **2. Goals and Standards**

##### 2.1 Benchmarks

Identify any specific state or national science standards or benchmarks that your curriculum is designed to meet. Note that we will use the AAAS benchmarks in discussions at the workshop itself. These are online at  
<<http://www.project2061.org/tools/benchol/bolframe.htm>>.

Benchmarks relevant to the middle school version of the curriculum include:

- Nature of Science: science knowledge is subject to change; scientific investigation involves gathering evidence and reasoning about evidence
- Physical Setting: Fresh water is essential for life; human activity affects the environment

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- Living Environment: all organisms depend on larger food webs; interactions between organisms may vary;
- Common Themes: Systems include processes and things; thinking about systems and their parts; connections between systems; models inform thinking about processes; different models can represent the same thing; systems tend to be stable until perturbed; reasons for stability; feedback systems;
- Habits of Mind: importance of clear and accurate records; value of hypotheses; that evidence can support multiple explanations; use computers to store and retrieve information; read analog and digital meters; read simple tables and graphs; find and describe locations on maps; question vague claims; be skeptical of arguments based on little data; be aware of multiple interpretations; criticize arguments

### 2.2 Cognitive learning goals

Describe any cognitive learning goals, related to science content or inquiry, that are not reflected in the benchmarks above.

The primary cognitive learning goals in the project are:

- Learning about coherent causal mechanisms, such as thermal pollution or eutrophication. These mechanisms typically involve several water quality factors. Rather than focusing on what students understand about the individual factors that can be measured (“what is dissolved oxygen”), we focus on helping students to understand the system of interactions that comprise the entire mechanism (“what affects dissolved oxygen, and what do changes in the amount of dissolved oxygen affect”). Assessment measures are targeted at how students understand the system and how it responds to changes (new inputs, potential remediation strategies, etc.).
- Focusing on mechanisms is an example of a knowledge integration learning goal. The overriding goal of the project, and all WISE projects, is to scaffold learners as they attempt to integrate their past experience, new information and evidence, and competing claims into a coherent whole.
- Scientific inquiry goals focus on the evaluation and use of evidence to support explanations for particular phenomena. In this case, students must make sense of water quality data and reconcile this data with their understanding of the causal relationships in the system and their expectations, based on empirical observation, of what is going on at the site.
- Students are also expected to be able to present, defend, and critique claims about what affects water quality (in their local watershed) and what might be done to improve it.

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### 3. Nature of the curriculum

#### 3.1. Curricular format

Is your curriculum paper-based? Web-based? How do you “package” your curriculum? Are there any financial costs associated with running the curriculum?

The WISE curriculum is entirely web-based, although it has been designed to be integrated with other water quality-related activities that teachers have been using. These activities include field trips to local watershed to gather water quality data and collect observations about the health of the stream, as well as lab-based activities that explore different water quality factors and produce data from field samples.

The curriculum is packaged within the WISE environment. Teachers who register at [wise.berkeley.edu](http://wise.berkeley.edu) can select a creek project and use it in their classroom for free. WISE also includes student management and assessment tools for the teacher.

WISE has as a technological requirement computers that have an Internet connection and that can run a modern (version 4 or better) web browser like Netscape or Internet Explorer. WISE recommends enough computers so that students may work together in pairs.

#### 3.2 Technological components

Describe any technologies used by the curriculum and their intended purpose.

There are three main technologies used within the WISE creek projects: the WISE environment, the causal mapping tool, and the data visualization tool. All three technologies are web-based.

WISE is itself a major technological component that supports student use of online projects as well as the generation and refinement of these projects. WISE manages student work, supports teacher and researcher assessment, and is designed to integrate with third party technologies such as the causal mapping tool and the data visualization environment. See <http://wise.berkeley.edu/>.

The causal mapping tool is a Java applet that runs within WISE. It allows students to generate a particular kind of concept map, where nodes represent causal factors and links represent the causal relationships between these factors. Students use the tool to generate causal maps that represent their understanding of water quality. See <http://cilt.berkeley.edu/synergy/causalmap/>.

The data visualization tool provides two different ways to make sense of stream water quality data. Such data consists of test results from multiple sites within the watershed, and may include data collected over a number of years. The tools

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uses two views — a map view and a graph view — to present the data. The map view shows the watershed region, usually via a satellite photo or some other scaled overhead view, with test sites highlighted. Students can select specific kinds of tests (e.g. pH, temperature) and view the site results in geographic relationship to one another. The graph view provides a more abstract view into the data, and allows students to compare two different tests, or the same test at two different times, to look for trends across time and across sites. Students can move between the two views at any time. A sample data set is viewable at <http://cilt.berkeley.edu/synergy/dataview/viewer/rocky/rockyCreekL.html>.

### 3.3 Activity structure

Describe the activity structure of the curriculum. This could include a lesson plan, an outline of the different activities, or examples of the actual materials. Explain how the activities within the curriculum form a coherent whole.

WISE creek projects all follow a general structure that varies a bit from project to project. The variation accounts for customizations that adapt the project to specific watersheds and focus the project on particular causal mechanisms such as eutrophication. These mechanisms determine the specific water quality indicators that are included in the project.

The general template includes the following elements:

- **Introduction/What's the Problem.** This activity frames the project and raises the questions that students will explore. Students may generate an initial model of water quality based on their own experiences, which they revise over the course of the project.
- **Indicator Factors.** Here, students learn how to tell whether or not a creek is healthy. They review a limited set of water quality indicator factors such as dissolved oxygen, macroinvertebrate levels, or pH. These factors are fairly direct indicators of the health of the aquatic ecosystem. The activity can include the review of site data to determine whether or not the site seems healthy or safe, but stops short of exploring why the site might be this way.
- **Mechanisms that affect water quality.** Here students explore the causal mechanisms, such as eutrophication or thermal pollution, which lead to changes in the health of a stream. This activity can also include a review of site data, but with the focus now on trying to identify the reason why a site might be polluted. Students can also use the causal mapping tool to build a visible representation of these relationships.
- **Live data collection.** When possible, students travel to the stream site to study the area, engage in inquiry and collect data for later analysis. We have designed tools to allow students to enter and analyze field data once they return to the classroom. (However, the actual data collection and accompanying field trip are not represented within WISE itself.)

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- Summary and reflections. A culminating activity in which students marshal evidence to argue about the state of the stream.

As an example, the Pine Creek project consists of six top level activities, each of which is comprised of several steps. Each activity takes about one 50-minute period. The top level activities are:

- Is your creek healthy? Introduces the project, sets the context to the local watershed. Prompts students to predict how healthy they think the creek is now, and why.
- Build a map of creek health. Introduces the causal mapping tool, solicits an initial causal map from the student that represents their initial understanding of what affects creek health and water quality.
- Indicators of creek health. Students learn more about pH, dissolved oxygen, and fecal coliform. Students make an initial assessment of the health of Pine Creek using data from the data visualization tool and comparing these values to existing water quality safety standards for drinking, swimming, and aquatic life.
- What affects creek health? Introduces the idea of causal chains (using causal map representation). Students learn about eutrophication, and return to the Pine Creek data to see if eutrophication might explain the data. Students build a second causal map to show how eutrophication occurs.
- Reflect on what you've learned. Students critique their initial causal map of water quality, and have a chance to revise it to reflect what they now understand.
- How can we improve creek health? Students are presented with a choice of remediation strategies in the context of a city council meeting; they have to make a recommendation for how to improve the creek and defend it. Students make recommendations in WISE, but also participate in a mock council meeting in class.

If you have a WISE account (they're free; visit [wise.berkeley.edu](http://wise.berkeley.edu) to create one), you can preview the middle school project, Pine Creek, by following this URL: <http://wise.berkeley.edu/student/startProject.php?projectID=2990>.

### 4. Curricular customization

*All of us design, and redesign, curricular materials, but we don't often talk about the process of redesign and how we build on initial successes and failures to continually improve our materials. This section asks you to reflect on the process of designing, and redesigning, curriculum.*

#### 4.1 Setting

Describe the typical classroom setting for your curriculum in terms of grade level, subject matter, period length, curriculum length, etc.

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The current target classroom is a middle school or high school science class where there is interest in learning more about a local watershed. The WISE creek project, which can be customized for the school's local environmental conditions, lasts from one to two weeks of 50-minute periods, depending on the number of environmental factors students will investigate and whether or not students study a comparison watershed.

At the middle school level, the unit is most appropriate for students taking earth science or life science. At high school, the unit has been used in chemistry, biology, and physics classes, although the curricular connections are stronger in the first two. The unit would also be appropriate for an environmental science class. Note that the particular causal factors that are explored can be customized to provide a better match to the class. For example, chemistry students might focus more on pH, nitrates, phosphates, and dissolved oxygen, while biology students study macroinvertebrates, temperature, and dissolved oxygen.

### 4.2 History

When was the curriculum first designed and used?

The curriculum was first designed in the fall of 1998 at Berkeley. We worked with two collaborating teachers at a local high school, and the development team included two CILT postdocs, a WISE postdoc, two doctoral students, one masters student who was student teaching at the school, and an environmental scientist.

Initially, a suite of three related projects were developed. The teachers at the high school taught biology, chemistry, and physics, and planned to take students from each class out to the local stream to do water quality testing. The WISE project was intended to provide context for this experience and also to provide some background information about the different factors that they would be testing for.

Students in the different classes were testing for different factors, so the three related projects were each customized for a different domain. However, the data from all three classes were made available to all students through the data visualization component.

This first use of the unit happened in the spring of 1999.

### 4.3 Evolution and iteration

How many times has the curriculum been redesigned? What were the significant changes (in the activity structure, in the learning goals, in the classroom setting, etc.) in each of these iterations? What prompted those changes?

The creek project has undergone five main cycles of revision/customization including the initial use. These include:

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- An initial customization of the WISE framework for the very first water quality project. The major issue that arose here was adapting WISE “evidence pages” as a means to provide background information about water quality factors. Previously, evidence pages invited critique: where did this evidence come from, who published it on the web, etc. We needed a means to help students learn about certain ideas for the very first time, and taking the time to pursue complete critiques of these pages didn’t fit into our curricular schedule.
- A rapid customization of the materials for use in another high school one month after the initial trial (spring 1999). This class was a biology class and would not be working with other chemistry and physics classes, so the project needed to be standalone. Due to time constraints, the changes here were primarily limited to adapting the unit for a new watershed and integrated water quality factors explored in the biology, chemistry, and physics projects into a single new project.
- An adaptation of the curriculum from high school to middle school (sixth grade), for use in the 1999-2000 school year. This adaptation also involved generating a new, related project that would be used in the fall, before students began to visit the stream site. The full project was used in the spring. Some changes were prompted by the change in grade level and the need to make materials more accessible to younger students. Empirical results from the first high school study led to refinements to the causal mapping tool and the data visualization environment.
- Construction of a short, “generic” water quality unit, called Drink or Swim, that was intended to be easily accessible to WISE teachers looking for a standard unit on water. This project prompted refinement of the data visualization tool and the design of a new “virtual” watershed that could be used in lieu of a local watershed. This project pared down much of the earlier projects to produce a unit that would take 3-4 days instead of 1-2 weeks.
- Further iteration of the middle school curriculum for the 2000-2001 school year. Changes prompted by the 1999-2000 study included refined prompts, a stronger focus on causal mechanisms, revised use of causal mapping to allow students to create multiple maps and reflect on how their maps have changes, and formal inclusion of the city council activity, that previously was a teacher-led discussion.

### 4.4 Examples of curricular change

Some changes are larger than others, but not everyone agrees about which changes are major and which changes are minor. Please give an example of what you would consider a major change that occurred during redesign and an example of what you would consider a minor change.

Major changes include:

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- Reordering activities.
- Adapting for new watersheds (sort of in between... not major for pedagogical approach, but major in that the particular circumstance dictates different factors to study).
- Rethinking the role of causal mapping within the project, and changes the way students are expected to use these maps.
- Rethinking what WISE evidence pages can be.

Minor changes include:

- Editing the text of WISE “evidence pages”, where students learn about specific water quality factors such as pH. These pages are tuned based on classroom observation and input from the design team, but such changes don’t fundamentally change the nature of the student’s interaction with the evidence.
- Editing or adding the prompts made by Amanda the Panda. Amanda is the vehicle for prompting students to think about

### 4.5 Justifying change

What kinds of evidence do you use to motivate and justify changes to the curriculum? Do certain kinds of evidence (e.g. teacher feedback, available classroom time, qualitative or quantitative data from classroom research studies, researcher or developer impressions from being in the classroom, etc.) carry greater weight in the redesign process? Is different evidence required to justify different kinds (e.g. major vs. minor) of change? Why?

Factors that lead to changes in our designs include:

- Observation and in class probing of students (by teacher and researcher, who touch base daily, informally). This often leads to immediate changes where curricular materials appear to be misleading or unclear. This could include rewording prompts, questions, or evidence, but generally not adding or changing actual activities. (WISE allows the project developer to make changes to the project on the fly, even once a classroom run has begun.)
- Analysis of student artifacts. Students’ notes are reviewed during the project by the teacher and after the project by researchers. New curricular change comes about to address documented weaknesses in student reasoning. Student causal maps provide examples of students’ initial and revised ideas of what affects water quality. Student causal maps have also prompted us to change the nature of the mapping task to integrate it better with the rest of the project (and make the maps “do work” for the students, instead of being a purely external task).

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- Student interviews provide an opportunity to see students use artifacts (such as their causal maps) to explain phenomena.
- Design group debriefing sessions allow all team members (teachers, researchers, designers) to share their thoughts on the classroom room. These sessions are primarily based on empirical observation and warrants and usually drawn from conversations with students. These sessions normally occur within a week or two of the end of the run and do not take into account student performance on posttests.
- Pre/post test results provide evidence to show how students are doing in terms of subject matter goals. The results of these tests focuses designers on particular concepts that students may be having trouble with, but usually doesn't directly influence the general nature of the curricular activities (e.g. the tests don't directly address whether inquiry is successful; other measures — observations, interviews — are used to assess that).

### 4.6 Curricular strengths and weaknesses

Given what you know now, what are the key strengths of your curriculum?  
Where is there room for improvement?

<b>Strengths</b>	<b>Weaknesses</b>
<p>Highly adaptable to new contexts and watersheds.</p> <p>WISE provides several scaffolds to encourage students to engage in structured inquiry.</p> <p>Knowledge integration approach is designed to help students integrate disparate ideas; a technique well suited to contexts like water quality where students need to understand complex, dynamic systems.</p> <p>Opportunities for students to articulate their understanding, through written notes and causal maps. Student generated artifacts also give teachers insight into student thinking.</p> <p>Data visualization environment uses multiple representations to support making sense of data.</p>	<p>Web-only evidence limited as means to learn about factors; need complementary classroom activities.</p> <p>No direct support for field trips and data collection activities during field trips. (Although some teachers have been working with WISE on the development of new tools to support this.)</p> <p>Still working on tying causal mapping activities to data analysis activities. Need to address how students make sense of data that conflicts with their causal maps.</p>

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### 5. Designing for customization

#### 5.1 Customization potential

We want to understand how your curriculum supports customization by teachers or other researchers. What aspects — technological support, activity structure, goals, materials, etc. — of your curriculum are critical (e.g. removing or changing some elements would make the curriculum ineffective)?

The critical aspects of our curriculum include:

- The use of an inquiry approach to learning about water quality. The project is situated within the activity of assessing a particular watershed, preferably one that the students know.
- A focus on constructing integrated understanding of how different water quality factors interact. A focus on understanding causal mechanisms, not just individual factors.
- Opportunities for students to generate and refine external models as a means to refine their understanding.
- Opportunities for students to make sense of empirical data.
- Students working in groups, preferably pairs.
- Internet access and available web browsers to run WISE.

What aspects of your curriculum are amenable to adaptation?

The flexible aspects of our curriculum include:

- The specific watershed used. While we prefer to tie WISE water projects to local watersheds so that students connect their own experience to their science learning, we recognize the trade-off between taking the time to customize a unit and using pre-existing material. Drink or Swim is a standalone WISE project that presents a fictional watershed scenario.
- Grade level. Grades 6-12 can use these materials in some form.
- The specific causal mechanisms and attending water quality factors that students explore. These should be relevant to the particular watershed and its issues.
- How testing is done. The curriculum itself does not teach students how to test for water quality.

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### 5.2 Design framework

Describe the design framework used within your research group. What are the major guiding principles that inform your curricular development process?

The design framework for the water projects derives from earlier work with the Computer as Learning Partner (CLP) and Knowledge Integration Environment (KIE) projects. Scaffolded Knowledge Integration (SKI) is an instructional framework that guides the development of the curriculum. SKI consists of four main principles:

- **Making Science Accessible.** Science is made accessible by allowing learners to connect new ideas to those they already have. Effective instruction should provide opportunities for students to evaluate scientific evidence according to their own personal understanding, to articulate their own theories and explanations, and participate actively in science learning. WISE software supports students in such understanding by emphasizing explanations and prompting for personal connections. We choose accessible topics and use models that students understand.
- **Making Thinking Visible.** To help students connect science instruction to their own understanding, their thinking needs to be made visible. WISE provides students with opportunities and software to represent their own thinking, as well as that of other students and even scientists, and to respond to one another's ideas. Thus, students receive feedback about their current models and can compare their models with others'.
- **Learning from Each Other.** Science learning is rarely performed in isolation from one's peers; rather, peer exchange is often vital to learning. This is true of real-world scientists and should also be true of classroom learning. Science instruction should be designed to foster collaborative work — because this will be an important skill for students throughout their lives, and also because it is an effective means of learning. WISE technology is designed to capitalize on the social nature of learning. Students work in pairs, and activities often call upon students to explain evidence to one another. Debates and electronic discussions help students share their ideas in a social context.
- **Promoting Autonomy.** Science instruction should prepare students for autonomous lifelong science learning. To do this, WISE presents students with accessible, independent activities that require sustained reasoning. To make such projects authentic, we draw on students' existing knowledge and incorporate scientific evidence that they find personally relevant. WISE on-line guidance is carefully designed to encourage reflection and exchange of ideas. Activities like critique, comparison and design are chosen because they will be important to students throughout their lives.

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### 5.3 Design process

Describe the design process used within your research group. Who participates in the design process, and at what stage? How frequently do you iterate? What kinds of evidence and warrants lead to design changes? How do you make (and document) design decisions?

Common practices within the CLP and KIE research groups also drove the design process. These practices included the importance of establishing a partnership that represented diverse expertise (teachers, researchers, technology experts, and scientists) and providing the design team with opportunities to critical review proposed learning goals and draft activities.

Typically, the design group first negotiates a set of shared cognitive learning goals for the project, and brainstorms a set of ideas for possible activities. This effort is informed by relevant literature as well as the partners' expertise.

An initial sacrificial draft will be circulated within the group to solicit critique and feedback. Based on feedback, a lead designers, usually a researcher, will iterate on a draft of the activity. Generally, a new curriculum will go through one to three review iterations before being ready for classroom use.

Warrants for design changes can come from impassioned argument as well as empirical evidence. Early in the design process, strong warrants are usually tied to the learning goals for the project, and in fact, often our arguments turn out to be arguments about learning goals at heart. Once projects have been run in the classroom, empirical evidence — from observation, student artifacts, and pre/post measures — becomes more valued.

Design decisions are documented informally through archived email of the groups' discussion and prior versions of the WISE project. However, there is no formal mechanism for documenting design decisions within the WISE group.

## 6. Assessment and Research

Include any citations that address these issues. *Please include with this profile any assessment instruments that you use with the curriculum.*

### 6.1 Student artifacts

What are the major student artifacts that are produced in this curriculum? How are they assessed?

Within the curriculum, students generate a set of reflective notes through the project. These notes are relatively short, one or two paragraph responses to cognitive and logistic prompts within WISE itself.

Teachers assess these notes using the WISE assessment manager. Teachers use their own coding schemes to assess student work. The WISE assessment manager

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constrains possible coding schemes to be numerical in nature (e.g. rating each note on a numerical scale) and allows teachers to leave specific comments for each student.

Students also produce and refine causal maps of water quality. These maps are similar to concept maps in appearance, but links between factors are limited to causal relationships such as “when X increases, Y decreases.” These maps are also available within the assessment manager for teacher review.

### 6.2. Assessment measures

What other assessment measures are used (by the teacher or the researcher) in the project? What is the purpose of these assessments?

Researchers assess student notes using a connection score approach, which is based on an instructional frame called knowledge integration. In this approach, we look for students’ ability to make connections among different pieces of evidence of information. Student responses are scored based on how students draw on evidence and synthesize knowledge.

We also analyze students’ causal maps for documented connections and compare these to student performance on pre/post measures. (Note: the connection seems tenuous.) We also look for change in these maps over the course of the project as an indication that the student is revising their understanding as they go. However, since these causal maps are intended to be a tool to support learning, not a representation of student understanding, we focus more on how they are using the maps.

Student interviews supplement pre/post measures by allowing the researcher to study student understanding in depth. These interviews also provide an opportunity to study how students speak about their causal maps and use them to answer questions and solve challenges posed by the interviewer.

Teacher interviews document the teacher’s perspective on the project enactment and also serve to capture the teacher’s design suggestions, based on their experience. These interviews are one instance of follow-up interviews with the design team, which have been videotaped as “focus group debriefing sessions”.

### 6.3. Findings

Summarize (or cite) any research findings that have emerged from your work.

Baumgartner, E., Cheng, B., Seethaler, S., & Slotta, J. (2000). *Strawberry Creek: A case of iterative curricular design*. Paper presented at the National Association for Research in Science Teaching, New Orleans, LA.

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Baumgartner, E., Seethaler, S., Cheng, B., Lo, E., & Slotta, J. (2000). *Online and midstream: The design of flexibly adaptive tools for understanding water quality*. Paper presented at the Annual meeting of the American Educational Research Association, New Orleans, LA.

Hsi, S., Collison, J., & Staudt, C. (2000). *Bridging web-based science learning with outdoor inquiry using Palm computers*. Paper presented at the Annual meeting of the American Educational Research Association, New Orleans, LA.

Seethaler, S., Baumgartner, E., & Linn, M. C. (2000). *Strawberry Creek: New web-based technologies to support student understanding of water quality through causal modeling and collaboration*. Paper presented at the Meeting of the American Chemical Society, San Francisco, California.