SCALE Project Profile

Overview

The purpose of this profile is to help us to generate a shared framework for comparing the design process and curricular product from different research and development groups. We ask you to describe your own water quality-related curriculum and also to reflect on the process of designing effective curricular materials. We will review and summarize responses from all participating projects prior to the workshop, and use your answers as a starting place for thinking about how we can work together to generate a shared curriculum that would have value for all of us.

Not all research groups will find all of these categories meaningful (or relevant). However, this represents a best attempt to provide a framing that allows each group to provide information about how they go about their work.

Instructions

Please complete as many of the sections of the profile as are relevant to your project. Please email the completed profile, along with any related files (e.g. assessment instruments, lesson plans, student artifacts) to Eric Baumgartner (ebaum@socrates.berkeley.edu) by September 14, 2001.

It's important that we receive a copy of this profile from you, even if in draft form, prior to the workshop. Further, the assessment team (Ken and Britte) really wants to start looking at assessment instruments prior to the workshop, so please send any assessment measures that you can. (Contact Britte at bcheng@socrates.berkeley.edu if you aren't sure exactly what assessments to send.)

The text in blue marks placeholders for your answers. Just edit this file and send it, along with any relevant assessment instruments, to Eric once you're done.

Thanks!

Eric, Marcia, and Jon

Project title: RiverWeb Water Quality Simulator (WQS)

1. Abstract

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

ABSTRACT

The RiverWeb WQS depicts a watershed and its subdivisions, each corresponding to a single land use. For example, station 0 monitors water quality in stream draining a pristine forest, while station 7, which represents an estuary, samples the common outflow, and therefore cumulative impacts on water quality across the entire watershed. Additional sub watersheds (stations 1-6) encompass lumbered, agricultural, suburban, industrial, wetland, and urban areas respectively. Upon selecting a location from an interactive map, the student modifies a form allowing selection of further station locations and physical or chemical indicators submits form requests to the server (via a “change display” button), then views simulation outputs as graphs. Thus students may compare how time series of two indicators vary within the same sub watershed, or how two different sub watersheds influence the variation of a single indicator. Indicators include water temperature, runoff, groundwater, nitrogen, phosphorus, heavy metals, toxins, sediments, dissolved oxygen, and pH.

Students may also implement a best management practice (BMP) to investigate how it mitigates water quality through its effects on runoff and other indicators, both locally and at the common outflow. Additional links include access to a scatter plot to explore putative quantitative relationships between selected indicators, background information on land uses and BMP’s, and the digital notebook

Our framework adapts the Jigsaw approach to team-based, cooperative learning in order to structure multiple learning activities, while supporting individual accountability during group work. To introduce a study of water quality to the class, the teacher delineates a scenario in which the students, representing various stakeholders, must prepare to testify before a hypothetical state commission on land use and best practice management. After discussing a newspaper report on local non-point pollution, for instance, students are introduced to fundamental concepts underlying the simulator. They take an interactive tour and then join a Jigsaw land use home group. Jigsaw indicator expert groups are used to help students determine the cause and effect of indicator variation across the watershed, and apply their insights in developing their recommendations.

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>.

The RiverWeb WQS Curriculum (potentially) meets these Maryland Core Learning Goals (i.e., it will take appropriate sequencing of activities, linked resources, teacher PCK, etc. to make this happen.)

Science Goal 1: Skills and Processes

Expectation 2: The student will pose scientific questions and suggest experimental approaches to provide answers to questions.

Indicator 2: The student will pose meaningful, answerable scientific questions.

Indicator 3: The student will formulate a working hypothesis

Expectation 4: The student will demonstrate that data analysis is a vital aspect of scientific inquiry and communication.

Indicator 2: The student will analyze data to make predictions, decisions, or draw conclusions.

Indicator 6: The student will describe trends revealed by the data

Indicator 8: The student will use models and computer simulations to extend his/her understanding of scientific concepts.

Expectation 5: The student will use appropriate methods for communicating in writing and orally the processes and results of scientific investigation.

Indicator 9: The student will communicate conclusions derived through a synthesis of ideas.

Expectation 7: the student will show that connections exist both within the various fields of science and other disciplines including mathematics, social studies, language arts, fine arts and technology.

Indicator 1: The student will apply the skills, processes, and concepts of biology, chemistry, Physics, and earth Science to societal issues.

Science Goal 2: Concepts of Earth and Space Science

Expectation 5: The student will know how to connect prior understanding and new experiences to evaluate natural cycles.

Indicator 1: The student will investigate various physical cycles found in the natural world (the water cycle only).

Science Goal 3: Concepts of Biology

Expectation 1: The student will be able to explain the correlation between the structure and function of biologically important molecules and their relationship to cell processes.

Indicator 1: the student will be able to describe the unique characteristics of chemical compounds and macromolecules utilized by living systems (water)

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 first two cognitive learning goals below are related to science goal 1, given above. They are however, somewhat broader. The third goal is not included above.

1) The student will describe the relationship between two variables depicted by a time series graph.

2) The student will depict complex relationships involved in the RiverWeb WQS using a concept map.

3) The student will use strategies such as goal setting to foster self-regulated learning.

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?

Our curriculum is web based. It includes the WQS simulator and student notebook, student resource pages and activity pages structured as unit and lesson plans (in development), and teacher guide (in development) emphasizing pedagogical content knowledge. The financial costs are associated with running the server and setting up individual notebooks that teachers or groups of teachers many personalize.

3.2 Technological components

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

Technologies used include

1) Computer models of system relationships between land use and water quality with an "archetypal" (geographically unspecified) river basin and, based on theses models, implementation of a web-based simulator within a client/server framework.

2) A web interface to the simulator enabling learners to select locations (i.e. sub watersheds, each corresponding to a distinct land use), choose indicators, and view model output in the form a graphs.

3) An interactive tour that introduces learners to key operations as well as the core scientific concepts behind the simulator.

4) A digital notebook in which students can record their observations, explanations, and hypotheses as they investigate water quality relationships, and teachers may structure, scaffold and assess student investigations.

Future planned components include:

1) A palate of tools to foster, record, and structure self regulated learning.

2) A presentation tool to allow students to combine simulator graphs and notebook questions / observations in a coherent analysis.

3) Concept mapper

In addition, the RiverWeb WQS will be part of a Collaborative Modeling Design Environment (CMDE), which will allow teachers to work together to modify simulation design and construct activity sets structured via questions and subquestions in the digital notebook.

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.

A typical scenario is given below. Customization is implied in the very design of the WQS since it supports open-ended exploration by scaffolding relationships between field variables. Depending on the background of students, they may engage in activities that help them gain prerequisite understanding in parallel with using the simulator. This would include activities developed by other SCALE water quality projects.

- Plot the route that rain falling on the school campus takes to the ocean, describing impurities the water might pick up on its way.
- Take the WQS Tour to become familiar with the simulator interface and time series graphs.
- Join the 'jigsaw' land use group to learn about particular indicators within a particular land use region.
- Share your knowledge of one of these indicators with students who studied the same indicator in the other land use regions.
- Contribute to the creation of a concept map, which depicts the connections between various water quality indicators.
- Return to your land use group to formulate recommendations for the county commissioners to implement best management practices.

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.

The target classroom features a secondary basic environmental science course. The Maryland State Department of Education specifies such a course. The ideal period length is 80-90 minutes, either every day for a semester, or every second day for a year. The length of time allocated for the WQS curriculum could range from 2 weeks to 9 weeks, depending on previous experience and range of activities selected. Other classes using the WQS have include secondary earth science, honors biology, general biology, and advanced placement environmental science. In addition, special middle school environmental science programs and community college environmental science programs have considered using the WQS curriculum. Discussions are underway on using the WQS as part of a team/interdisciplinary approach.

4.2 History

When was the curriculum first designed and used?

A precursor of the curriculum was used in 1996 as part of the Stream Collaborative Project of the Maryland Virtual High School. Classes collected monthly stream data, shared it through the Internet and used a STELLA model to analyzed relationships between water quality variables.

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 1997-1998 the curriculum was redesigned as a classroom activity modeling paper packet accompanying a STELLA model. The purpose of the redesign was to emphasize pertinent Maryland Core Learning Goals and the AAAS Benchmark common themes.

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.

A major change we made was in 2000 in moving from a STELLA based model of a single watershed to a web-based client server model of an archetypal watershed with sub watersheds defined by one land use. Changing to a web-based environment has many ramifications for extending use to a broader audience. The pre-2000 curriculum was based on handouts guiding students through the model investigation. It also included instructions to build one part of the model based on determining a relationship between precipitation and runoff. In the 2000 curriculum, such “modeling experience” has been replaced by student concept map development. In addition, peer interaction was formalized through a jigsaw activity structure.

A minor change we made was in integrating the WQS tour as an early part of the curriculum. The length of the tour was shortened. The purpose was limited to introducing the WQS interface and very basic concepts of time series.

Another minor change was in designing the digital notebook questions to be considered by particular students. As part of the research agenda, students might answer questions determined by the teacher, or questions they determined as necessary to meet specific objectives. (Goal setting).

The major change to the archetypal watershed with sub watersheds defined by land use has required the development of a much more extensive curriculum. Additional funding will be required to guide and support teachers in helping to develop it. Model materials are being developed for investigating indicator relationships within a particular land use area and for comparing the variation of a particular indictor over many land uses. These materials may then be reviewed and adapted for additional land use areas and indicators. We would also like to offer a choice of overall unit plans that include activities from other SCALE projects.

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 feedback from teachers indicating relative importance of key concepts, prerequisite knowledge, and related prerequisite/co-requisite activities such as wet labs. Data from student artifacts and assessments has led us to define a ranking or water quality conceptual models reflecting student understanding.

In addition, we have found that teachers are very sensitive to student feedback. They often wish to revise activities that are not immediately engaging to students. This can include activities that are too simplistic for self-motivated students, as well as activities that are perceived by unprepared students as confusing and difficult (insufficient or ineffective scaffolding).

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?

Strengths	**Weaknesses**
Curriculum tied to state and national learning goals Cognitive objectives tied to theory. Linking science and mathematics cognitive goals. Research agenda investigating process and results of objective attainment. Embedding of student artifacts in the learning process to provide a basis for authentic assessment.	Dependence of parts of curriculum on prerequisite content knowledge not specified. Missing content resources for prerequisite knowledge. Teachers request more control on co-requisite resources available to students. Pedagogical content knowledge for teachers needs to be integrated into entire activity structure. Omission of explicit links to "outside the web" activities other than web lab activities. (e.g. field observations.)

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

1) Student control over display of time series of related variables for a given sub-watershed, or of the same variable for sub-watersheds with a given land use.

2) An activity structure that fosters peer and teacher scaffolding. For example, in a jigsaw formulation land use groups recombine to form indicator (e.g. runoff, nitrates, dissolved oxygen) “expert groups” who determine how and particularly **why** these substances vary from one place to another.

What aspects of your curriculum are amenable to adaptation?

The flexible aspects of our curriculum include the use of the digital notebook. Many teachers are initially more comfortable with paper based handouts that students complete and submit for grading. Teachers may choose among preloaded notebook questions, or replace some or all questions with their own. Teacher adaptation provides for a desired focus on particular indicators, particular land use, or particular concept development.

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?

(Note – this is from one of our AIED chapters – it's too much, but something might be useful copied for a report, etc.)

The underlying theoretical framework for our research is based on a social constructivist perspective [2-4]. Social constructivism, an approach to learning in which students construct knowledge through their interactions with and interpretations of their world [5] includes four fundamental features —active construction, situated cognition, community, and discourse. Research has shown that students are more likely to develop a deep understanding when they are provided with opportunities to actively construct their understanding of a discipline [6-10]. Actively engaging in understanding requires that learners become immersed in the content of a discipline, which provides learning situations featuring increasingly autonomous activity, together with social and intellectual support. Learners' socialization into the culture of scientific inquiry is a critical component of this project, which involves developing close collaboration with the teachers and students of the Maryland Virtual High School (MVHS). A goal of this project is to create a Modeling Inquiry Community (MIC) to support high school students' structured scientific explorations using Web-based simulation environments. Participation within any community requires the use of language to exchange and negotiate meaning of ideas among its members. Language becomes a critical component as learners are introduced into the community by more competent others (i.e., teachers) and use language to learn how to participate in the community, construct learning, and engage in the discourse of the community.

We have used the social constructivist perspective to collaborate with teachers, university researchers, educational researchers, and curriculum developers, deriving curriculum design principles similar to those adopted by other educational researchers [1,2,4,8,9] to develop extended science inquiry activities using the WQS. These seven principles include context, standards-based, inquiry, collaboration, learning tools, artifacts, and scaffolds. In RiverWeb learners are provided with a context in which they solve meaningful and challenging science problems using the various components of the WQS. The activities are standards-based, in that students engage in activities based on benchmarks and standards from the larger scientific community (e.g., AAAS) [11] related to practices and methods for asking questions and solving problems, emphasizing the effect of the human presence on the earth, and common themes such as systems and dynamic change. Students engage in sustained inquiry activities, which is the accepted norm in the scientific community for solving problems. By engaging in sustained scientific investigations, students learn to collect, analyze, interpret, share information, and negotiate the meaning of information. To successfully participate in a community of learners the students must collaborate by interacting with peers, teachers, and community members to share information and negotiate meaning. The integration of Web-based learning environments such as RiverWeb are used to support students' scientific reasoning by allowing students to pose science questions, propose hypotheses, view scientific data, modify arguments, share data and negotiate about its meaning. Students create artifacts (e.g., concept maps, scientific models, lab reports, notebook entries, and group presentations) as they conduct scientific investigations. These artifacts are external representations of ideas that can be shared, critiqued, and revised to enhance learning. The use of scaffolds to support student learning is strongly associated with the four fundamental features of social constructivism − active construction, situated cognition, community, and discourse. Here, the assistance of more competent members of the community can be used to assist more novice learners to accomplish more difficult tasks. The MVHS community provides scaffolding at several levels—(1) projects are designed to guide learning as students are introduced to challenging science problems; (2) learning materials (e.g., digital notebook) are designed to reduce complexity, foster the use of inquiry strategies, foster collaboration; and, (3) because the Web-based environment is used in the classroom teachers have the opportunity to model, coach, articulate and externalize their reasoning, and give feedback whenever possible.

[1] Linn, M., & Hsi, S. (2000). Computers, teachers, peers: Science learning partners. Mawah, NJ: Erlbaum.

[2] Blumenfled, P., Marx, R., Patrick, H., & Krajcik, J. (1997). Teaching for understanding. In B. Biddle, T. Good, & I. Goodson (Eds.), International handbook of teachers and teaching (pp. 819-878). Netherlands: Kluwer.

[3] Cobb, P. (1994). Where is the mind? Constructivistic and sociocultural perspectives on mathematical development. Educational Researcher, 23(7), 13-20.

[4] Singer, J., Marx, R., Krajick, J., & Chambers, J. (2000). Constructing extended inquiry projects: Curriculum materials for science education reform. Educational Psychologist, 35(3), 165-178.

[5] Rogoff, B. (1999). Cognition as a collaborative process. In W. Damon, D. Kuhn, & R. Siegler (Eds.) Handbook of child psychology (vol. 2) (pp. 679-744). NY: Wiley.

[6] Azevedo, R., Guthrie, J.T., Wang, H., & Mulhern, J. (2001). Do different instructional interventions facilitate students’ ability to shift to more sophisticated mental models of complex systems? Paper to be presented at the Annual Conference of the American Educational Research Association, Seattle, WA.

[7] Lajoie, S.P., & Azevedo, R. (2000). Cognitive tools for medical informatics. In S.P. Lajoie (Ed.), Computers as cognitive tools II: No more walls: Theory change, paradigm shifts and their influence on the use of computers for instructional purposes (pp. 247-271). Mahwah, NJ: Erlbaum.

[8] Songer, N. B. (1996). Exploring learning opportunities in coordinated network-enhanced classrooms: A case of Kids as Global Scientists. The Journal of the Learning Sciences, 5(4), 297-327.

[9] Wallace, R., Kupperman, J., Krajcik, J., & Soloway, E. (2000). Science on the web: Students online in a sixth-grade classroom. Journal of the Learning Sciences, 9(1), 75-104.

[10] Perkins, D., Crismond, D., Simmons, R., & Unger, C. (1995). Inside understanding. In D. Perkins, J. Schwartz, West, M., & Wiske, M. (Eds.), Software goes to school: Teaching for understanding with new technologies (pp. 70-87). NY: Oxford University Press.

[11] American Association for the Advancement of Science. (1993). Benchmarks for science literacy. NY: Oxford.

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?

The RiverWeb Water Quality Simulator (WQS)1 is part of an ongoing, collaborative design experiment to refine tools and strategies supporting inquiry into watershed dynamics, particularly physical, chemical, and biological processes determining water quality. The WQS builds on and extends the Maryland Virtual High School (MVHS) Core Models Project in which teachers collaborate to develop and implement computer modeling activities designed to promote core science concepts such as the interdependence of ecological systems. WQS prototyping is also linked into RiverWebSM Program from the National Center for Supercomputing Applications (NCSA) that leverages emerging modelling, simulation, visualisation, interaction, and web technologies to develop digital river basins with which diverse learners can explore and study river basin processes in formal or informal settings including museums and science centers.

The main members of out team include Mary Ellen Verona, (MVHS) RiverWeb WQS PI, David Curtis (NCSA) RiverWeb WQS Co-PI, Roger Azevedo (University of Maryland) educational psychologist and primary classroom researcher, Donald Schaffer (MVHS – North East High School), RiverWeb WQS co-developer, Susan Ragan (MVHS) and Stacy Pritchett (MVHS) master teacher. At least part of the team meets weekly during classroom implementation. Major meetings are held at the beginning and end of each cycle of classroom implementation.

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?

Students generate digital notebook entries, concept maps and panel presentations. Only preliminary work has been done in assessing the notebook entries and panel presentations. We are in the midst of formalizing our assessment of the concept maps. An initial scoring tool is based on the number of terms and relationships within the map. Our new formalization is based on rating student maps in comparison to “mental models” of water quality relationships. A sophisticated mental model includes the dependence of dissolved oxygen level on both water temperature and phosphate indicator level (for example), fleshing out the dependence of both branches on more basic

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dependent variables, and independent variables. Less sophisticated models do not include all dependencies, or include links that duplicate indirect dependencies with direct dependencies.

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?

The primary assessment measures include pre and post tests comprised of essay questions, graph interpretation exercises, and concept map completion questions. The purpose of these assessments is to determine the development of student mental models of watershed system relationships focusing on water quality. In addition, ability of student to illustrate relationships by comparing relevant time series is assessed. The oral presentation to the hypothetical land use committee has been used as a cumulative assessment.

6.3. Findings

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

Findings include the importance to teachers of opportunities for customization and gaining just in time pedagogical content knowledge. The RiverWeb WQS fostered student engagement in sustained inquiry-based activities and scientific reasoning. Student difficulties included comparing and analyzing multiple representations, reformulating hypotheses, and defining tasks. Findings have been published in

Azevedo, R., Verona, M.E., & Cromley, J.G. (2001). Fostering students' collaborative problem solving with RiverWeb. In J.D. Moore, C.L. Redfield, & W.L. Johnson (Eds.), Artificial intelligence in education: AI-ED in the wired and wireless future (pp. 166-175). Amsterdam: IOS press

Verona, M.E., Curtis, D., & Shaffer, D. (2001). Supporting teacher development in enacting the RiverWeb Water Quality Simulator. In J.D. Moore, C.L. Redfield, & W.L. Johnson (Eds.), Artificial intelligence in education: AI-ED in the wired and wireless future (pp. 87-98. Amsterdam: IOS press

Additional findings submitted to AERA, 2002 (Azevedo, Ragan, Cromley, and Pritchett) involve the investigation of students' self-regulated learning, teachers' roles, and classroom discourse. Specifically, the paper discusses variable effects of teacher and student goal setting on student learning.