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: Geoscience Environmental Education – Web-accessible Instrumented Systems (GEE-WIS)

1. Abstract

The basic components of this project are the instrumentation of two small lakes on the UConn campus, Mirror and Swan Lake, with data made accessible via the Web in real time stream (http://www.mypond.uconn.edu), and a corresponding educational site (http://www.geewis.uconn.edu) for use by high school and undergraduate students and teachers. A team of marine science, biology, engineering and education faculty have installed YSI probes in order to obtain water quality profiles at 30 minute intervals.

Anchored instruction scenarios were developed to invite high school and college students to understand the Internet real-time authentic pond water quality data. A framework based on Ecological Psychology was used to emphasize perception-action over memory-retrieval as the fundamental process of learning (see Young, Barab, Garrett, 2001). Drawing on concepts of seamless assessment (e.g., Kulikowich & Young, 2000) and the full integration of situated learning with anchored assessment, we provided online teacher and student discussion and support materials to support customization of anchored instruction. Our methodology applied a combination of quantitative and qualitative techniques in the context of a design experiment focused on the development and refinement of an anchored problem-solving learning context through prototype development work with three high school teachers.

2. Goals and Standards

2.1 Benchmarks

1. The Nature of Science

1. B. Scientific Inquiry

- Investigations are conducted for different reasons, including to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare different theories.
- Hypotheses are widely used in science for choosing what data to pay attention to and what additional data to seek, and for guiding the interpretation of the data (both new and previously available).

1. C. The Scientific Enterprise

- Science disciplines differ from one another in what is studied, techniques used, and outcomes sought, but they share a common purpose and philosophy, and all are part of the same scientific enterprise. Although each discipline provides a conceptual structure for organizing and pursuing knowledge, many problems are studied by scientists using information and skills from many disciplines. Disciplines do not have fixed boundaries, and it happens that new scientific disciplines are being formed where existing ones meet and that some subdisciplines spin off to become new disciplines in their own right.

- Scientists can bring information, insights, and analytical skills to bear on matters of public concern. Acting in their areas of expertise, scientists can help people understand the likely causes of events and estimate their possible effects. Outside their areas of expertise, however, scientists should enjoy no special credibility. And where their own personal, institutional, or community interests are at stake, scientists as a group can be expected to be no less biased than other groups are about their perceived interests.

2. The Nature of Mathematics

2.A. Patterns and Relationships

- Mathematics is the study of any patterns or relationships, whereas natural science is concerned only with those patterns that are relevant to the observable world. Although mathematics began long ago in practical problems, it soon focused on abstractions from the material world, and then on even more abstract relationships among those abstractions.

2.B. Mathematics, Science and Technology

- Mathematical modeling aids in technological design by simulating how a proposed system would theoretically behave.
- Mathematics and science as enterprises share many values and features: belief in order, ideals of honesty and openness, the importance of criticism by colleagues, and the essential role played by imagination.
- Mathematics provides a precise language for science and technology—to describe objects and events, to characterize relationships between variables, and to argue logically.
- Developments in science or technology often stimulate innovations in mathematics by presenting new kinds of problems to be solved. In particular, the development of computer technology (which itself relies on mathematics) has generated new kinds of problems and methods of work in mathematics.
- Developments in mathematics often stimulate innovations in science and technology.

2.C. Mathematical Inquiry

- Much of the work of mathematicians involves a modeling cycle, which consists of three steps: (1) using abstractions to represent things or ideas, (2) manipulating the abstractions according to some logical rules, and (3) checking how well the results match the original things or ideas. If the match is not considered good enough, a new round of abstraction and manipulation may begin. The actual thinking need not go through these processes in logical order but may shift from one to another in any order.

3. The Nature of Technology

3.A. Technology and Science

- Technological problems often create a demand for new scientific knowledge, and new technologies make it possible for scientists to extend their research in new ways or to undertake entirely new lines of research. The very availability of new technology itself often sparks scientific advances.

- Mathematics, creativity, logic and originality are all needed to improve technology.
- Technology usually affects society more directly than science because it solves practical problems and serves human needs (and may create new problems and needs). In contrast, science affects society mainly by stimulating and satisfying people's curiosity and occasionally by enlarging or challenging their views of what the world is like.

3.B. DESIGN AND SYSTEMS

- The value of any given technology may be different for different groups of people and at different points in time.
- Complex systems have layers of controls. Some controls operate particular parts of the system and some control other controls. Even fully automatic systems require human control at some point.

3.C. ISSUES IN TECHNOLOGY

- The human species has a major impact on other species in many ways: reducing the amount of the earth's surface available to those other species, interfering with their food sources, changing the temperature and chemical composition of their habitats, introducing foreign species into their ecosystems, and altering organisms directly through selective breeding and genetic engineering.
- Human inventiveness has brought new risks as well as improvements to human existence.

4. THE PHYSICAL SETTING

4.C. PROCESSES THAT SHAPE THE EARTH

- Plants alter the earth's atmosphere by removing carbon dioxide from it, using the carbon to make sugars and releasing oxygen. This process is responsible for the oxygen content of the air.

4.D. THE STRUCTURE OF MATTER

- The rate of reactions among atoms and molecules depends on how often they encounter one another, which is affected by the concentration, pressure, and temperature of the reacting materials. Some atoms and molecules are highly effective in encouraging the interaction of others.

4.E. ENERGY TRANSFORMATIONS

- Whenever the amount of energy in one place or form diminishes, the amount in other places or forms increases by the same amount.
- Heat energy in a material consists of the disordered motions of its atoms or molecules. In any interactions of atoms or molecules, the statistical odds are that they will end up with less order than they began—that is, with the heat energy spread out more evenly. With huge numbers of atoms and molecules, the greater disorder is almost certain.

- Transformations of energy usually produce some energy in the form of heat, which spreads around by radiation or conduction into cooler places. Although just as much total energy remains, its being spread out more evenly means less can be done with it.

5. The Living Environment

5.C. Cells

- Most cells function best within a narrow range of temperature and acidity. At very low temperatures, reaction rates are too slow. High temperatures and/or extremes of acidity can irreversibly change the structure of most protein molecules. Even small changes in acidity can alter the molecules and how they interact. Both single cells and multicellular organisms have molecules that help to keep the cell's acidity within a narrow range.

5.D. Interdependence of Life

- Ecosystems can be reasonably stable over hundreds or thousands of years. As any population of organisms grows, it is held in check by one or more environmental factors: depletion of food or nesting sites, increased loss to increased numbers of predators, or parasites. If a disaster such as flood or fire occurs, the damaged ecosystem is likely to recover in stages that eventually result in a system similar to the original one.
- Like many complex systems, ecosystems tend to have cyclic fluctuations around a state of rough equilibrium. In the long run, however, ecosystems always change when climate changes or when one or more new species appear as a result of migration or local evolution.
- Human beings are part of the earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.

5.E. Flow of Matter and Energy

- At times, environmental conditions are such that plants and marine organisms grow faster than decomposers can recycle them back to the environment. Layers of energy-rich organic material have been gradually turned into great coal beds and oil pools by the pressure of the overlying earth. By burning these fossil fuels, people are passing most of the stored energy back into the environment as heat and releasing large amounts of carbon dioxide.
- The amount of life any environment can support is limited by the available energy, water, oxygen, and minerals, and by the ability of ecosystems to recycle the residue of dead organic materials. Human activities and technology can change the flow and reduce the fertility of the land.
- The chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways. At each link in a food web, some energy is stored in newly made structures but much is dissipated into the environment as heat. Continual input of energy from sunlight keeps the process going.

7. Human Society

7.B. GROUP BEHAVIOR

- Social organizations may serve business, political, or social purposes beyond those for which they officially exist, including unstated ones such as excluding certain categories of people from activities.

8. THE DESIGNED WORLD

8.B. MATERIALS AND MANUFACTURING

- Waste management includes considerations of quantity, safety, degradability, and cost. It requires social and technological innovations, because waste-disposal problems are political and economic as well as technical.

8.E. INFORMATION PROCESSING

- Computer modeling explores the logical consequences of a set of instructions and a set of data. The instructions and data input of a computer model try to represent the real world so the computer can show what would actually happen. In this way, computers assist people in making decisions by simulating the consequences of different possible decisions.

9. THE MATHEMATICAL WORLD

9.B. SYMBOLIC RELATIONSHIPS

- In some cases, the more of something there is, the more rapidly it may change (as the number of births is proportional to the size of the population). In other cases, the rate of change of something depends on how much there is of something else (as the rate of change of speed is proportional to the amount of force acting).
- Symbolic statements can be manipulated by rules of mathematical logic to produce other statements of the same relationship, which may show some interesting aspect more clearly. Symbolic statements can be combined to look for values of variables that will satisfy all of them at the same time.
- Any mathematical model, graphic or algebraic, is limited in how well it can represent how the world works. The usefulness of a mathematical model for predicting may be limited by uncertainties in measurements, by neglect of some important influences, or by requiring too much computation.
- Tables, graphs, and symbols are alternative ways of representing data and relationships that can be translated from one to another.
- When a relationship is represented in symbols, numbers can be substituted for all but one of the symbols and the possible value of the remaining symbol computed. Sometimes the relationship may be satisfied by one value, sometimes more than one, and sometimes maybe not at all.

9.D. UNCERTAINTY

- Even when there are plentiful data, it may not be obvious what mathematical model to use to make predictions from them or there may be insufficient computing power to use some models.
- The way data are displayed can make a big difference in how they are interpreted.

- A physical or mathematical model can be used to estimate the probability of real-world events.

9.E. Reasoning

- To be convincing, an argument needs to have both true statements and valid connections among them. Formal logic is mostly about connections among statements, not about whether they are true. People sometimes use poor logic even if they begin with true statements, and sometimes they use logic that begins with untrue statements.

11. Common Themes

11.A. Systems

- A system usually has some properties that are different from those of its parts, but appear because of the interaction of those parts.
- Understanding how things work and designing solutions to problems of almost any kind can be facilitated by systems analysis. In defining a system, it is important to specify its boundaries and subsystems, indicate its relation to other systems, and identify what its input and its output are expected to be.
- The successful operation of a designed system usually involves feedback. The feedback of output from some parts of a system to input of other parts can be used to encourage what is going on in a system, discourage it, or reduce its discrepancy from some desired value. The stability of a system can be greater when it includes appropriate feedback mechanisms.
- Even in some very simple systems, it may not always be possible to predict accurately the result of changing some part or connection.

11.B. Models

- The basic idea of mathematical modeling is to find a mathematical relationship that behaves in the same ways as the objects or processes under investigation. A mathematical model may give insight about how something really works or may fit observations very well without any intuitive meaning.
- Computers have greatly improved the power and use of mathematical models by performing computations that are very long, very complicated, or repetitive. Therefore computers can show the consequences of applying complex rules or of changing the rules. The graphic capabilities of computers make them useful in the design and testing of devices and structures and in the simulation of complicated processes.
- The usefulness of a model can be tested by comparing its predictions to actual observations in the real world. But a close match does not necessarily mean that the model is the only "true" model or the only one that would work.

11.C. Constancy and Change

- A system in equilibrium may return to the same state of equilibrium if the disturbances it experiences are small. But large disturbances may cause it to escape that equilibrium and eventually settle into some other state of equilibrium.

- Along with the theory of atoms, the concept of the conservation of matter led to revolutionary advances in chemical science. The concept of conservation of energy is at the heart of advances in fields as diverse as the study of nuclear particles and the study of the origin of the universe.
- Things can change in detail but remain the same in general (the players change, but the team remains; cells are replaced, but the organism remains). Sometimes counterbalancing changes are necessary for a thing to retain its essential constancy in the presence of changing conditions.
- Graphs and equations are useful (and often equivalent) ways for depicting and analyzing patterns of change.
- In many physical, biological, and social systems, changes in one direction tend to produce opposing (but somewhat delayed) influences, leading to repetitive cycles of behavior.
- In evolutionary change, the present arises from the materials and forms of the past, more or less gradually, and in ways that can be explained.
- Most systems above the molecular level involve so many parts and forces and are so sensitive to tiny differences in conditions that their precise behavior is unpredictable, even if all the rules for change are known. Predictable or not, the precise future of a system is not completely determined by its present state and circumstances but also depends on the fundamentally uncertain outcomes of events on the atomic scale.

11.D. Scale

- Representing large numbers in terms of powers of ten makes it easier to think about them and to compare things that are greatly different.
- Because different properties are not affected to the same degree by changes in scale, large changes in scale typically change the way that things work in physical, biological, or social systems.
- As the number of parts of a system increases, the number of possible interactions between pairs of parts increases much more rapidly.

12. Habits of Mind

12.A. Values and Attitudes

- Know why curiosity, honesty, openness, and skepticism are so highly regarded in science and how they are incorporated into the way science is carried out; exhibit those traits in their own lives and value them in others.
- View science and technology thoughtfully, being neither categorically antagonistic nor uncritically positive.

12.B. Computation and Estimation

- Use ratios and proportions, including constant rates, in appropriate problems.
- Find answers to problems by substituting numerical values in simple algebraic formulas and judge whether the answer is reasonable by reviewing the process and checking against typical values.

- Make up and write out simple algorithms for solving problems that take several steps.
- Use computer spreadsheet, graphing, and database programs to assist in quantitative analysis.
- Compare data for two groups by representing their averages and spreads graphically.
- Express and compare very small and very large numbers using powers-of-ten notation.
- Trace the source of any large disparity between an estimate and the calculated answer.
- Recall immediately the relations among 10, 100, 1000, 1 million, and 1 billion (knowing, for example, that 1 million is a thousand thousands).
- Consider the possible effects of measurement errors on calculations.

12.C. MANIPULATION AND OBSERVATION

- Learn quickly the proper use of new instruments by following instructions in manuals or by taking instructions from an experienced user.
- Use computers for producing tables and graphs and for making spreadsheet calculations.

12.D. COMMUNICATION SKILLS

- Make and interpret scale drawings.
- Write clear, step-by-step instructions for conducting investigations, operating something, or following a procedure.
- Choose appropriate summary statistics to describe group differences, always indicating the spread of the data as well as the data's central tendencies.
- Describe spatial relationships in geometric terms such as perpendicular, parallel, tangent, similar, congruent, and symmetrical.
- Use and correctly interpret relational terms such as if . . . then . . . , and, or, sufficient, necessary, some, every, not, correlates with, and causes.
- Participate in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration, and expressing alternative positions.
- Use tables, charts, and graphs in making arguments and claims in oral and written presentations.

12.E. CRITICAL RESPONSE SKILLS

- Notice and criticize arguments based on the faulty, incomplete, or misleading use of numbers, such as in instances when (1) average results are reported, but not the amount of variation around the average, (2) a percentage or fraction is given, but not the total sample size (as in "9 out of 10 dentists recommend..."), (3) absolute and proportional quantities are mixed (as in "3,400 more robberies in our city last year, whereas other cities had an increase of less than 1%), or (4) results are reported with overstated precision (as in representing 13 out of 19 students as 68.42%).

- Check graphs to see that they do not misrepresent results by using inappropriate scales or by failing to specify the axes clearly.
- Wonder how likely it is that some event of interest might have occurred just by chance.
- Insist that the critical assumptions behind any line of reasoning be made explicit so that the validity of the position being taken—whether one's own or that of others—can be judged.
- Be aware, when considering claims, that when people try to prove a point, they may select only the data that support it and ignore any that would contradict it.
- Suggest alternative ways of explaining data and criticize arguments in which data, explanations, or conclusions are represented as the only ones worth consideration, with no mention of other possibilities. Similarly, suggest alternative trade-offs in decisions and designs and criticize those in which major trade-offs are not acknowledged.

2.2 Cognitive learning goals

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

Project learning goals...

3. Nature of the curriculum

3.1. Curricular format

Currently, our curriculum is strictly Web-based, being implemented in a few classrooms beginning this Fall. Our curriculum is packaged into two separate websites. The website (http://www.mypond.uconn.edu) that is being maintained by the Department of Marine Sciences contains the real-time water quality data, as well as archived data. The anchored instruction scenarios and other resources for students and teachers are located at the education website (http://www.geewis.uconn.edu).

Currently, there are no direct costs (???) of running the curriculum in a classroom. Our website is being designed as a supplemental resource to teachers who already have a water quality component within their curriculum. The anchored instruction scenarios and other resources available at GEE-WIS are to be integrated into the teachers' existing water quality units.

3.2 Technological components

The technological components required for GEE-WIS are as follows:

- A computer;
- Internet access (preferably high speed access);
- A web-browser; and
- Microsoft Office®.

3.3 Activity structure

Students (or a teacher demonstrates) navigate to the website (http://www.geewis.uconn.edu). Clicking on the link entitled "Anchor Problems."

This link takes the student to the list on Anchor Problem scenarios. The student clicks on the problem that s/he wants to download. A PowerPoint scenario is downloaded to the student's computer. The student then plays the PowerPoint show and is lead into the problem.

The other links on the GEE-WIS site are designed to provide resources to the students as they attempt to answer the problems using the real-time data.

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

The classroom settings are currently being determined. There are two undergraduate classrooms (approximately junior level, beginning of major course of study) participating in GEE-WIS. During the fall of 2001, an Environmental Engineering class will work on the problems. During the spring of 2002, a Marine Science class will work on the problems. We have recently recruited three high school science teachers to implement GEE-WIS into their classes.

4.2 History

The project began in February 2001, with the procurement of the funds. The probes were installed during the summer of 2001 in both Mirror and Swan Lakes. The educational website (GEE-WIS, http://www.geewis.uconn.edu) was developed during the summer of 2001. The real-time data site is currently (fall 2001) beginning its operation (MyPond, http://www.mypond.uconn.edu).

The first anchor problem scenario was tested this summer with a group of educators during a daylong work session, hosted by an Environmental Engineering Professor and Dr. Michael F. Young, Associate Professor of Education.

Three high school teachers are beginning to pilot the reworked problem in their classrooms this school year.

4.3 Evolution and iteration

As described in the section above, GEE-WIS is in its developmental stages and is constantly being developed. The first anchor problem was recently revised based on information obtained during a daylong work session with educators during the summer of 2001. The changes included the addition of specific water quality data (embedded data) to the scenario to provide a basis for the family's complaint in the first scenario. The data indicates an increase in nitrates in the family's well water, which is located near the ponds being studied. Furthermore, information regarding the construction of graduate dorms by an independent contractor near the pond was included to enhance issues of environmental engineering.

4.4 Examples of curricular change

In the infancy of our project, the changes have been ongoing and are generally part of the development of the project.

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 will lead to changes in our designs we believe will include all of the above methodologies.

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**

· The combination of real-time water quality data, with anchored instruction. · Student use of authentic data to solve problems. · Collaborative efforts in design by the Neag School of Education and the Marine Sciences Department. · Open design of the GEE-WIS website to support customization. · Interaction with active University science.	· Infancy of design, which creates the need for: · Development of assessments; and · Lack of specific, guided scaffolding (need data to design it).

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...

What aspects of your curriculum are amenable to adaptation?

The flexible aspects of our curriculum include...

5.2 Design framework

Educational research supports the critical importance of creating a realistic context in the classroom that is engaging to students.

A framework based on Ecological Psychology was used to emphasize perception-action over memory-retrieval as the fundamental process of learning (see Young, Barab, Garrett, 2001). Drawing on concepts of seamless assessment (e.g., Kulikowich & Young, 2000) and the full integration of situated learning with anchored assessment, we provided online teacher and student discussion and support materials to support customization of anchored instruction. Our methodology applied a combination of quantitative and qualitative techniques in the context of a design experiment focused on the development and refinement of an anchored problem-solving learning context through prototype development work with three high school teachers.

Theories of situated learning, instructional approaches such as anchored instruction, and successful K-12, UG geoscience efforts, all recommend that students be engaged in a "macrocontext" that situates learning in the authentic practices of scientists, politicians, and/or citizens. This increases the probability that students will detect the usefulness of geoscience knowledge as a tool for solving problems in their own real world; that is, they will detect the information's raison d'être and be able to transfer learning from the classroom to their own lives.

GEE-WIS and MyPond have been designed in order to (1) provide opportunities to learn, (2) provide the tools to extrapolate from personal experience (the best learning tool) (3) appreciate the scientific/economic couplings and feedback loops that affect their daily lives and (4) appreciate the temporal response of coupled systems, and (5) mindfully engage both undergraduate and K-12 students in construction of understanding concerning coupled dynamic environments across multiple scales (lab water, pond water, and the waters of Long Island Sound).

5.3 Design process

Our design process is unique as a result of the collaborative dynamics that exist between the “Educators” and the “Marine Scientists.” We are working with one professor/principle investigator from the department of Marine Sciences, as well as several PhD graduate students/assistants from Marine Sciences. The scientists are teaching the educators, the educators are teaching the scientists. Feedback throughout the design process is sought from the scientists, formal and informal meetings are held to discuss further design iterations.

Feedback from teachers and students are (and will be) sought through interviews as well as formal assessments. As discussed earlier, since GEE-WIS and MyPond are in their infancy, new iterations are constantly being developed.

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

Students will provide fact-based arguments to support or refute contentions within the anchor problem scenarios. The cases will be evaluated by an “expert panel” consisting of…???

6.2.Assessment measures

Assessment measures have not yet been designed. However, the assessments will include qualitative data obtained through teacher and student interviews, and other qualitative data obtained through our cooperative work with the marine scientists. Furthermore, assessments will be designed to determine the depth of student interpretation of data, comparing students who have used the anchor problems and those students who have not used the problems.

6.3. Findings

Since our project has not been tested in a class room as to this point, we are not ready to provide any findings.