1. Abstract

The driving question of this project, “What is the water like in our river?”, leads students to investigate watersheds, the movement of water, and relationships among the surrounding landscape and an aquatic ecosystem. When students look more closely at the quality of the water in their river they investigate chemical and physical factors that affect water quality, and the relationship between water quality and biodiversity.

Student understanding is facilitated by actively engaging with phenomena. During the project, students ask questions, conduct experiments (e.g. cause and effects of fertilizer and acidity on plant growth; water quality testing) and draw conclusions. Learning is also supported through the construction of physical (watershed and stream tables) and dynamic models (Model-it). Constructing models of their river helps learners integrate each concept into their understanding of aquatic ecosystems. Learning technologies are an integral part of this inquiry process. Specifically, learners use Model-It, a dynamic modeling tool, to construct a model of their aquatic ecosystem. As student understanding grows so does their model. Students continually plan, build, test and evaluate their model based on the inquiry activities they engage in.

At the conclusion of the project students construct a final artifact. Students chose the format and the focus of their artifact. Using multimedia displays or Model-It, students present their model of how land use or physical or chemical factors affect water quality in their river or how water quality can impact the biodiversity of their river.

2. Goals and Standards

While this project does provide opportunities for students to conduct “controlled” experiments, collect water quality data, and learn about fundamental hydrology concepts (erosion, deposition, run-off) the fundamental ideas that the unit aspires to facilitate are associated with systems and models (AAAS benchmarks Chpt 11 (A and B)). During the unit students construct a series of models (watersheds, stream-tables, model-it) and participate in discussions concerning the limitations and advantages of the various representations. The repeated use of model-it provides the opportunity for students to illustrate the increased complexity of a watershed system.

- AAAS Grade 6 – 8 11A #1A system can include processes as well as things.
- AAAS Grade 6 – 8 11A #2 Thinking about things as systems means looking for how every part relates to others. The output from one part of a system (which can include material, energy, or information) can become the input to other parts. Such feedback can serve to control what goes on in the system as a whole.
- AAAS Grade 6 – 8 11A #3 Any system is usually connected to other systems, both internally and externally. Thus a system may be thought of as containing subsystems and as being a subsystem of a larger system.
- AAAS Grade 6 – 8 11B #1 Models are often used to think about processes that happen too slowly, too quickly, or on too small a scale to observe directly, or that are too vast to be changed deliberately, or that are potentially dangerous.
- AAAS Grade 6 – 8 11B #3 Different models can be used to represent the same thing. What kind of a model to use and how complex it should be depends on its purpose.

The usefulness of a model may be limited if it is too simple or if it is needlessly complicated. Choosing a useful model is one of the instances in which intuition and creativity come into play in science, mathematics, and engineering.

- AAAS Grade 6-8, 4C #7 Human activities, such as reducing the amount of forest cover, increasing the amount and variety of chemicals released into the atmosphere, and intensive farming, have changed the earth's land, oceans, and atmosphere. Some of these changes have decreased the capacity of the environment to support some life forms.
- AAAS Grade 6-8, 4B #8 Fresh water, limited in supply, is essential for life and also for most industrial processes. Rivers, lakes, and groundwater can be depleted or polluted, becoming unavailable or unsuitable for life.
- AAAS Grade 6-8, 1B #1 Scientists differ greatly in what phenomena they study and how they go about their work. Although there is no fixed set of steps that all scientists follow, scientific investigations usually involve the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected evidence.
- AAAS Grade 6-8, 1B #2 If more than one variable changes at the same time in an experiment, the outcome of the experiment may not be clearly attributable to any one of the variables. It may not always be possible to prevent outside variables from influencing the outcome of an investigation (or even to identify all of the variables), but collaboration among investigators can often lead to research designs that are able to deal with such situations.
- AAAS Grade 6- 8 1C #7 Accurate record-keeping, openness, and replication are essential for maintaining an investigator's credibility with other scientists and society.

3. Curricular enactment

This Middle school curriculum is approximately expands 35 – 40 class periods based upon an average 50 minute period. The project has been enacted in selected Detroit schools since the spring of 1997.

4. Activities, Technology, curricular format

The curriculum is paper based of approximately 150 pages. Curriculum materials include detailed lesson plans, Background content information for teachers, a brief overview of the curricular design principles, and connections to local standards. In addition to the teacher lesson plans, a student workbook, reader and CD (containing a virtual tour and supplementary materials) is also provided to teachers.

The curricular materials are organized around the tenets of Project-based science as described by Blumenfeld et al. 1991; Krajcik et. al 1998, Singer et al. 2000.

Driving Questions

This unit is structured around a "Driving Question -- What is the water like in our river? A Driving Question should be consistent with existing curriculum frame-works, including district and state guidelines; encompass real-world questions that students find meaningful; engage students in inquiry over an extended period; students develop the knowledge and skills necessary to answer the question.

Learning Sets and Sessions

In this project, the Driving Question is divided into four related sub-questions. Learning Sets are organized around a sub-question that contains related concepts and activities. The purpose of the sub-questions is to facilitate the students in constructing a response that demonstrates their emergent understanding. Learning Sets last 1-4 weeks, depending on the complexity of the concepts being focused on. Each Learning Set begins with the purpose of the Learning Set, a calendar, background content information, an overview and detailed lesson plans.

Learning Sets in this project include:

Learning Set 1
Bringing the River Inside
Learning Set 2
Where is My River Located?
Learning Set 3
What Impacts Water Quality?
Learning Set 4

What is the Quality of Water in Our River? Learning sets are further divided into sessions that include specific activities focusing on a single concept. They provide information about the topic of the learning set and, ultimately, the driving question. Sessions last 1-4days and contain detailed plans for enacting an activity.

Teacher Planning and Reflection Pages These pages will be located at the end of each session to support the teachers in adapting the project to their specific classroom.

Icons Throughout this unit, icons are used to represent key aspects of the project, such as teaching strategies, content information, technology, and anchoring experiences. These icons, found in the margins, are meant to help teachers enact the project by highlighting and providing helpful hints.

Technologies

The major technology utilized in the curriculum is the qualitative modeling tool model-it. The central focus of model-it was to provide cohesion and illustrate connections between the different aspects of the curriculum project.

Model-It is a dynamic modeling tool that allows the learner to easily plan, build, test and evaluate dynamic qualitative models and engages students in communicating, representing, refining, and extending their understanding (Jackson, Stratford, Krajcik & Soloway, 1996). The program allows the learner to make qualitative models of cause and effect relationships. Using Model-It, the user creates objects with which he or she associates measurable, variable quantities called variables and then defines relationships between those variables to illustrate the effects of one factor upon another. Relationships can be model immediate effects or effects over time. Model-It provides facilities for testing a model and a “factor map” for visualizing it as a whole. Students define objects, variables and the relationships between variables’ qualities. The student is facilitated in this process by a variety of scaffolds. These scaffolds include features that

a) allow for multiple linked representations, b) options that hide additional complexity, c) learner guidance through sub-tasks and d) prompting for explanations for constructed relationships.

Customization Issues

- Level of technology integration. Model-it is well integrated with the learning activities. Supports may be too structured. Student models collected during the course of the unit do show a definite trend in complexity as evinced from an increase in the quantity and variety of variables, objects and relationships represented. Comparison of student models at similar iterations increase in diversity across successive iterations (Singer et al. , NARST 2001).
- Student understanding of basic hydrology concepts (run-off, erosion, deposition). Students show substantial pre to post test gains on these topics. And sample of students interviewed performed well on interviews protocols.
- Students conduct water quality tests but it seems to be more “mechanical” than understanding what the tests indicate.
- Length of curriculum is a serious enactment concern. Most teachers can not complete the curriculum and either rush through activities, skipping opportunities for students to synthesize information or cutting whole sections of the curriculum. As described in Singer et al. 2000 (examples are from “air unit” but instances do occur in this unit”) Teachers are fine enacting the activity but have shown difficulty facilitating students in making meaning of big ideas and how activities connect across within a project. Strategies attempted have been creating project maps that show connections between activities, assessments and standards. If teachers determine to cut or alter instruction they can see the big picture. No systematic data collection has been done to determine the effectiveness of the project maps.
- Proximity to a body of water is a major issue. What to do with classrooms that do not have access to a river/stream? Have attempted using a virtual river. CD designed to illustrate the “local” river, where it is situated relative to the school. During water quality testing water samples are brought in to the classrooms.
- Inquiry tends to be very “guided” Students have limited opportunities to ask and follow through with their own questions. Beginning of projects student ideas are solicited but as project unfolds, student ideas are seldom revisited or incorporated. Also as projects unfold teachers tend to lose sight of the driving question and focus instead on the specific concept of the current session. (losing sight of the forest for the tree syndrome) Observational data.

Design and Development

Curriculum materials are initially designed through a small workgroup consisting of curriculum developers, teacher/developers, and discipline experts. Based upon district needs, a series of standard/benchmarks are targeted. This stage is then followed with a cycle of adjusting, standards, context (driving question and related sub-questions) and the specific activities to be included. Once consensus is reached within the workgroup. The curriculum developer (University post-doc or grad. Student) begins constructing the specific lesson plans. Structure of the specific lessons and their sequence are dictated by PBS design principles. Certain strategies do tend to be utilized frequently such as POE’s, KWL’s, group pair shares, and learning cycle formats. Draft lessons are shared and critiqued by a larger work group containing at least one senior member of the research center, a content expert and multiple teachers. Feedback is recorded and revisions are made. Specific aspects critiqued include: the driving questions and sub-questions, the level of inquiry, technology integration, scientific accuracy, connection to standards and assessments. This cycle may continue for multiple iterations. Once a first polished draft is developed the unit is reviewed by the associate superintendent of Detroit Public schools to critique based upon agreement with district standards. After a polished draft is completed a pretest and post test is developed. The test is designed to conform to a predetermined design structure based upon the number of open ended and multiple choice items and question difficulty (questions are determined to be High, medium or low based upon certain criteria) Tests tend to be approximately 20 questions with 2 – 3 open ended items. See Tal et al. NARST 2000. Test construction goes through a similar process of critique as the curriculum.

The next phase of curriculum development is the pilot phase. Generally 1 – 3 classrooms are selected and the unit is piloted. Curriculum developer now becomes the lead professional development agent. During the pilot the developer meets regularly with the enacting teachers, making classroom observations multiple times a week and weekly discussions with the teachers to gain insights of what is working well, what may need to be changed as well as discussing pedagogical strategies observed (or not observed) during recent enactments. At the start of the pilot the lead developer will discuss with the teachers what the key project artifacts are and what items need to be collected. Target students (approx. 4 students who are generally “B” students) are studied in depth generally through collection of student work and interviews. Upon completion of pilot, the curriculum is critiqued based upon classroom observations, pre/post test scores, teacher input and student artifacts. The enact – revise cycle continues after each enactment of a curriculum project. The water quality project has been through 5 or 6 cycles.