Summer 1996

An Interdisciplinary Water Quality Curriculum for Middle School Students

Barbara Michelle Cleveland

Central Washington University

AN INTERDISCIPLINARY WATER QUALITY CURRICULUM FOR MIDDLE SCHOOL STUDENTS

A Project Report

Presented to

The Graduate Faculty

Central Washington University

In Partial Fulfillment

of the Requirements for the Degree

Master of Education

---

by

Barbara Michelle Cleveland

May, 1996

AN INTERDISCIPLINARY WATER QUALITY CURRICULUM
FOR MIDDLE SCHOOL STUDENTS

by

Barbara M. Cleveland

June, 1996

An interdisciplinary curriculum correlating water quality with the disciplines of physical science and mathematics for 6th grade middle school students was developed. Literature examined indicates that the opportunity to explore key concepts and significant issues using an integrated approach provided greater opportunity to formulate meaningful connections between disciplines studied and that achievement was enhanced. The Learning units were developed for use at Wilson Middle School in Yakima, Washington.

TABLE OF CONTENTS

Page

CHAPTER ONE

BACKGROUND OF THE PROJECT

Introduction

Current middle school curriculum delivery is largely based on subject content taught in isolation. For example, science is usually taught in separation from subjects such as mathematics, reading, or social studies (Hart, 1989; Beane, 1991). Preparing students for the rapidly changing, complex, and competitive world they will face as adults involves more than providing mastery of isolated and often disconnected content information.

Knowledge is not something that is caught like a cold or the flu. In order to frame understanding into meaningful schemes, a larger context within which to evaluate experiences is required. In this regard, evaluation, or problem solving, is essential to the purpose of knowledge acquisition. Jacobs (1989) suggests, "there is a need to actively show students how different subject areas influence their lives, and it is critical that students see the strength of each discipline perspective in a connected way" (p. 5). Opportunities to explore and consider key questions and significant issues are often missed as a result of the single discipline approach to teaching (Brady, 1993).

An integrated curriculum is considered an alternative to isolated subject delivery and the problems of pertinence. The use of integrated curriculum can promote inquiry and reasoning, discovery and relevance, allowing students to explore the broader implications of content information. Emphasis in this type of design is placed on the relationships between ideas and their relevance to larger issues, not on rote memorization of unrelated facts and segmented information (Clark & Clark, 1994; Carnegie Council on Adolescent Development, 1989).

Current curriculum delivery is based partly on the idea that learning in one area of study will naturally be transferred and applied to new situations when encountered. Educators are beginning to understand that this approach often inhibits synthesis of knowledge and understanding. Connections established between isolated or fragmented information become active links that present a truer picture of reality. Terms such as coherent, and relevant curriculum are used to express this move toward the development of meaningful curriculum (Beane, 1995b).

It has been the author's observation that adolescence is often viewed as a time of rebelliousness and of disagreeable and contentious social and emotional behavior. Negative labels are easily, and often, attached to students in this age group. Recognition should, however, be given to adolescents as eager and active participants in society, as individuals deeply concerned about the issues facing their world (Jacobs, 1995).

One common issue of concern to adolescents is the quality and condition of the environment. Hardly a day goes by without news items related to water issues, however, few students are aware of the importance of water and its quality or the many human impacts which can affect it. Awareness and understanding of the relationship between ourselves and the environment need to be strengthened, and responsible stewardship of the water we depend on for life emphasized (Brady, 1989; Environmental Protection Agency, 1992; Gore, 1992; Orr, 1995). Creating a cohesive, relevant learning environment through the implementation of integrated curriculum is appropriate when considering characteristics of middle school students as deeply concerned about their environment and eager participants in the larger society.

Statement of Problem

The separate subject approach to curriculum delivery is typical in most middle schools (Jacobs, 1989), yet researchers suggest that this typical instructional method is incompatible with the cognitive and social character of adolescents (Eccles, Wigfield, Midgley, Reuman, Mac Iver, & Feldhaufer, 1993). Brady (1993, p. 439), concerned about the separate subject approach, writes:

> [academic disciplines] have nothing to say about the relative importance of various kinds of knowledge. They do not give students a mental framework for organizing and relating what they are taught. Because they cannot be made to integrate with one another, they fail to disclose the systemic nature of reality.

The call to dissolve boundaries between discipline fields is shared by the Washington State Commission on Student Learnings in Science. In a 1995 draft proposal of work in progress, the commission calls for students to be able to "understand the interdependence among the different branches of science, technology, and mathematics, and their connections to the world beyond the science class" (p. 29).

The Yakima School District Science Education Statement of Philosophy (1995) asserts that science should be integrated with other disciplines, that real-life problem solving should be addressed in the curriculum, and that knowledge of environmental issues related to physical science should be taught.

Purpose of the Project

The purpose of this project was to develop an interdisciplinary curriculum correlating the environmental issue of water quality with the disciplines of physical science and mathematics for sixth grade students at Wilson Middle School in Yakima, Washington.

The lessons, projects, and activities presented in this interdisciplinary curriculum were developed for their compatibility with the physical science and mathematics curriculum currently used in the sixth grade at Wilson Middle School.

Limitations of the Project

The limitations of the study are as follows:

1) The results of this study may not be generalized beyond the sixth grade at Wilson Middle School in Yakima Washington.
2) Formal assessment to determine the effectiveness of this interdisciplinary curriculum when compared to a

separate subject approach was not conducted.

3) The adoption of this project may be constrained by the availability of technology necessary to perform water quality measurements, and the accessibility to a stream, river or creek.

4) School scheduling may present a limitation on implementation of the project depending on the ability to block schedule math and science.

Definition of Terms

As used in this study the following terms will be defined as follows:

Discipline - A specific body of teachable knowledge with its own background of education, training, procedures, methods, and content areas (Jacobs, 1989, p. 7).

Environment - The sum of all external conditions affecting the life, development, and survival of an organism. (Environmental Protection Agency, 1989, p. 7).

Integrated curriculum - A curriculum approach which synthesizes learning across traditional subject lines, and in which learning experiences are arranged in order to be mutually reinforcing (Mansfield, 1989).

Interdisciplinary curriculum - A knowledge view and curriculum approach that consciously applies methodology and language from more than one discipline to examine a central theme, issue, problem, topic, or experience (Jacobs, 1989, p. 8).

Multidisciplinary curriculum - The juxtaposition of several disciplines focused on one problem with no direct attempt to integrate (Jacobs, 1989, p. 8).

Water Quality - Water resource issues and specific levels of water quality which, if reached, are expected to render a body of water suitable for its designated use, and the environmental conditions affecting that quality. (Environmental Protection Agency, 1989).

Organization of the Remainder of the Project

Chapter 2 is a review of literature and research summaries organized to address separate subject curriculum as a problem, justification for curriculum integration, justification for integration of science and mathematics, and justification for environmental education. Chapter 3 includes an analysis of current state and local curriculum requirements as well as the methodology used to develop the project. Chapter 4 consists of an explanation of the project, student expectations, unit requirements and the project lesson plans and activities. Chapter 5 summarizes the project and offers conclusions and recommendations concerning the project study.

CHAPTER 2

REVIEW OF RELATED LITERATURE

Introduction

The review of literature and research summaries included in Chapter 2 have been organized to address the following concerns:

1. Separate subject curriculum as a problem
2. Justification for curriculum integration
3. Justification for integrating science and mathematics
4. Justification for environmental education

Separate Subject Curriculum as a Problem

Curriculum for most middle schools in America can be characterized by distinct and separate content material delivered in isolation by subject specialists (Beane, 1995b; Clark & Clark, 1994; Hart, 1989). The strong historical tradition of the separate subject approach is apparent in the factory-model schools of the nineteenth-century. These schools stressed efficiency and compliance in the delivery of curriculum that was designed to prepare students for an industrial society (Fiske, 1989; Hart, 1989). Established within the separate subject approach is the notion that disciplines studied in separation leads to important learning (Vars, 1969).

Many reforms are taking place in American education, yet the single subject approach to curriculum delivery remains a prominent feature (Beane, 1990; Hart, 1989). One explanation for the continuation of this design is efficiency gained in the implementation of curriculum content. The separate subject design is a systematic, efficient response to state and locally mandated educational requirements that are often set in terms of seat time or minutes per week (Jacobs, 1989).

State and local mandates proliferated after the release of the study entitled *A Nation At Risk* published by the National Commission on Educational Excellence in 1983 (Adelman & Pringle 1995). The Commission, examining the quality of education in the United States, suggested that a crisis existed. The Commission reported statistics indicating a serious decline in literacy and academic achievement, maintaining that immediate educational reforms were necessary for Americans to maintain a global competitive edge.

One reform the Commission was interested in establishing, primarily in high-school education, called for increased time spent in certain subject classes. That pressure to extend seat time at the high-school was eventually passed on to middle schools (Beane, 1990).

Nineteenth century factory model schools, stressing obedience more than problem solving, intended to prepare students for a world and for work they could expect to encounter. Holdovers to passive, authoritarian practices are still evident in the school schedule and the strict movement of students from discipline to discipline as well as in the repetitive read, write, and recite model of curriculum delivery (Hart, 1989).

Researchers suggest that current curriculum practices are insufficient given the need for greater intellectual diversity, and creative, critical thinking (Edwards, 1991; Fiske, 1989). According to Brady (1989) "our best minds tell us that all knowledge is related, yet our curriculum is fragmented and the fragments are moving farther apart" (p. 9). Beane (1990) addresses the shortcomings of separate subject designs by suggesting that curriculum fragmentation disconnects knowledge, limiting necessary access to linked understanding, and creating "a distorted view of real life as it is commonly experienced by people" (p. 29). Teaching separate subjects constrains patterns of understanding, and thinking becomes a process of fragmenting the importance of various kinds of knowledge (Brady, 1989). Bits of information that are separated or compartmentalized inhibit flexible thinking and the value and meaning behind concepts, the contextual relevance, is limited (Ackerman, 1989).

National organizations such as The Carnegie Council on Adolescent Development (1989) have expressed concern over the fragmentation issue. The council suggests that most adolescents are being taught through the use of seemingly irrelevant curricula, and in this manner American middle schools are not meeting the developmental needs of students (p. 13).

Justification for Curriculum Integration

Curriculum improvement is one aspect of the growing national concern over educational reform (Anson & Fox, 1995). Jacobs (1989) suggests there are serious concerns in curriculum design and implementation when 25% of students are dropping out of school (p. 4). Shanker (1990) cites a 1988 report from the National Assessment of Educational Progress (NAEP) when referring to significantly low academic and proficiency scores of American students. The NAEP report, titled "Crossroads in American Education", assessed reading, math, and science performances over a twenty year period. Referring to the study, Shanker indicated that student performance was barely above mastery of basic information.

Fragmented, separate subject curriculum is problematic in school restructuring efforts. A possible solution exists in using curriculum that emphasizes the interconnected nature of subjects brought about through integration techniques (Hart, 1989). Consider the following excerpt from John Dewey (1938, p. 48) who provides insight into the need to deviate from partitioning the learning experiences of students,

> When the question is asked, then, what has become of [the learning] where has it gone to, the right answer is that it is still there in the special compartment in which it was originally stowed away. If exactly the same conditions recurred as those under which it was acquired, it would also recur and be available. But it was segregated when it was acquired and hence is so disconnected from the rest of experience that it is not available under the actual conditions of life.

Interest in ameliorating the disconnected nature of single subject curriculum and providing sustained and accessible relevance through integration is significant among middle school educators (Beane, 1991; Jacobs 1989). Curriculum that creates conscious links between subject areas can provide a filter through which to explore expanded understanding. It is the value and significance behind concepts, their interrelatedness that will ultimately establish knowledge and comprehension (Ackerman, 1989; Beane, 1995b; Carnegie Council on Adolescent Development, 1989; Jacobs 1989).

Experimental research supporting the hypothesis that integrated curricula and learning retention or academic achievement are linked were conspicuous by their rarity, however, in much of the literature known to this author, researchers assume a strong positive correlation.

The ability to synthesize information, to solve problems or to think independently is tied to the capacity for recognizing patterns of relevance between disciplines (Palmer, 1995). Perkins (1989) offers that Integrative learning stimulates higher-order thinking skills as students recognize universal patterns or evaluate and synthesize broader interpretations of subjects as they are revealed. Glatthorn (1994) asserts that the holistic approach to learning illustrated by an integrated curriculum design improves retention, access, and application of knowledge.

Concerning the validity of curriculum integration, Vars (1995) discloses that researchers, conducting studies during the past 40 years, indicate that students involved in interdisciplinary programs do as well, if not better, on standardized tests than students in separate subject programs. Spivak and Schwarts (cited in Vars, 1995) disclose that "students who complete an interdisciplinary program in middle or junior high school usually make normal or better marks in high school" (p. 18).

Additional support for curriculum integration comes from The Carnegie Council on Adolescent Development (1989). In *Turning Points,* a report on the education of America's young adolescents, the Council suggests that key reforms are necessary for the intellectual development and personal growth of young adolescents. The Council believes that most middle school curriculum is fragmented and irrelevant, and it promotes the use of integration techniques, suggesting middle school curriculum reflect inquiry and reasoning across disciplines.

The relationship of literacy and learning to the arrangement of mutually reinforcing disciplines is currently debated under titles such as multidisciplinary integration and interdisciplinary integration (Jacobs, 1989). Multidisciplinary curriculum involves the alignment of separate disciplines so that each focuses on a similar topic or theme. For example, a mathematics teacher and a science teacher may re-sequence curriculum in order that the study of electricity be taught during lessons on the Industrial Revolution under a common theme of "cause and effect". In this example lessons in one area would correspond to and shed light on the other discipline.

Advantages of a multidisciplinary integration model include that obvious links between complementary fields of knowledge can be arranged and curricular designs can be readily managed (Jacobs, 1989).

Interdisciplinary design differs in that a range of disciplines are brought together and content is selected and connected according to a centralized principle (Jacobs, 1989). According to Beane (1995a) interdisciplinary designs unify disciplines using an organizing principle that cannot be fully understood through any one discipline alone, such as Music History or Environmental Engineering. An organizing principle can be a question, issue, theme or a topic. An example of an organizing principle for an interdisciplinary curriculum is one that asks the question "are we experiencing a modern day Renaissance?" The question is then used to conjoin the discipline perspectives of science, social studies, language arts, and music in a mutually supportive way.

Interdisciplinary curriculum should be designed and implemented carefully, drawing on experiences of researchers in the field. A sensible method for creating interdisciplinary units is essential for success (Vars, 1995). Glatthorn (1994) believes that integrated curriculum is best developed by individual schools working within the existing district and state adopted curriculum guidelines. Jacobs (1991, p. 2) suggests the following four step approach for the careful development of integrated units of study:

1. Identify the organizing center
   -consider possible draft titles (issues, themes, problems, topics, works,...)
   -consider the approximate time frame

-consider the characteristics of your specific target population

2. Brainstorm associations related to the organizing center using the disciplines

   -first with teachers

   -then with students

3. Devise a set of essential questions to frame the unit as a scope and sequence

   -critical to long-term learning

   -focus on conceptual priorities

4. Generate activities and assessments under each essential question for implementation

Kovalik (cited in Willis, 1992, p.39) stresses the importance of creating meaningful and pragmatic curriculum. She believes that choosing an appropriate theme is perhaps the most vital component for success and provides the following questions to consider for evaluating a theme and the resulting curriculum:

1. What is so important about this theme that it will promote future learning?
2. Does it have substance and application to the real world?
3. Are relevant materials readily available?
4. Is it meaningful and age-appropriate?
5. Does it tie into other units, enabling students to make generalizations and have greater understanding?
6. Is it worth the time needed to create and implement it?

Beane (1992) concurs with the importance of creating curriculum that initiates deeper understanding stressing that student involvement in the design phase is imperative. He suggests that interdisciplinary curriculum should:

1. Explicitly involve questions from the young adolescents who will carry out the unit
2. Involve a concern that is widely shared by young adolescents, involve larger world concerns that are of clear social significance
3. Potentially engage a wide range of knowledge and resources, pose opportunities for in-depth work
4. Present possibilities for a wide range of activities
5. Present possibilities for action, including outside the school. (p. 39)

Justification for Integrating Science and Mathematics

Concern about American students low mathematics and science aptitude scores is well documented. Berlin (1989), and Hart (1989), cite National Association of Educational Progress (NAEP) scores, reporting a trend of decreasing achievement in these subjects. Rutherford and Ahlgren (1990) submit "there is now a strong clear national consensus in the United States that all elementary and secondary school children need to become better educated in science, mathematics, and technology" (p. 196). Former Secretary of Education, Lamar Alexander suggests that educational achievement has not significantly improved over time submitting that "today's children seem to know about as much math and about as much science and read about as well as their parents did at that age 20 years ago" (cited in Ralph, Keller, & Crouse, 1994, p. 145).

Traditional methods of teaching science and mathematics, with an emphasis on content coverage rather than conceptual understanding, may inhibit significant improvements in science and mathematics education (Davidson, Miller & Methaney, 1995; Steen, 1991). Typical middle school instructional practices that are often teacher controlled may inhibit student's independent thinking and sustain lower levels of comprehension (Turner & Meyer, 1995).

The necessity for improvement in science and math education is commonly accepted (Fort, 1993; National Commission on Excellence in Education, 1983; National Council of Teachers of Mathematics, 1989; Palincsar, Anderson & David, 1993; Rutherford & Ahlgren, 1990; Shanker, 1990; Steen, 1991). Researchers suggest that these curriculua could be improved by increasing inquiry and de-emphasizing the focus on quantity of material covered. In response to improving science and mathematics proficiency, the need to consider integration is evident in suggestions that include mathematical resaoning and problem solving as it would naturally emerge from the separate disciplines (National Teachers of Mathematics, 1989; Rutherford & Ahlgren, 1990).

In a summary of relevant literature, Macbride and Silverman (1991, pp. 286-287) promote the intertwining of science and mathematics and suggest four rationales for integration:

1. Science and mathematics are closely related systems of thought and are naturally correlated in the physical world
2. Science can provide students with concrete examples of abstract mathematical ideas that can improve learning of mathematics concepts
3. Mathematics can enable students to achieve deeper understanding of science concepts by providing ways to quantify and explain science relationships
4. Science activities illustrating mathematics concepts can provide relevancy and motivation for learning mathematics

Integrating mathematics and science can enhance understanding and proficiency in solving problems in each of the respective fields of study. Since mathematical operations are often used to describe scientific principles, using mathematics in conjunction with laboratory experiences of a science classroom can reduce the abstract nature of some operations (Berlin, 1989; Friend, 1985; Lawson & Bealer, 1984; McBride & Silverman, 1991; National Council of Teachers of Mathematics, 1991).

Justification for Environmental Education

Regarding the importance of including environmental perspective as part of school curriculum Harrington (1990) writes:

The child who is not taught that the abuse of land can lead to the downfall of nations has been deprived of one of the most valuable lessons that history can teach. Some knowledge of both the resilience and the fragility of the earth is as much a part of basic education as reading and writing. (pp. 43-44)

Brady (1989) acknowledges the pragmatic need for environmental education as necessary for a human systems awareness or perspective. He suggests that the welfare of mankind is dependent upon an understanding of the relationship between the physical and biological aspects of the earth.

Vice President Gore (1992) stresses the importance of environmental awareness stating the "rescue of the environment [should be] the central organizing principle for civilization (p. 269). Environmental Protection Agency (EPA) administrator, William K. Reilly, agrees adding that a stronger custodial relationship for the environment needs to be cultivated. Reilly suggests that environmental stewardship is required in order to ensure and protect the health of our global habitat (cited in Environmental Protection Agency, 1992). The EPA further confirmed a commitment to the promotion of environmental literacy by establishing an office for the distribution of educational materials to schools (1992).

The presence of environmental science education programs have increased in schools across the nation (Environment, 1994), and in the state of Washington the inclusion of environmental studies as part of the curriculum is clearly called for. The Revised Code of Washington (RCW) 28A.230.020 states that common school curriculum should include "science with special reference to the environment" (1990, p. 475).

Science education has typically been delivered so that in each year a separate science is studied, perhaps biology one year, chemistry another, and physics yet another (Brunkhorst, 1991). Just as an interdisciplinary curriculum approach can provide connections between disciplines, so can integration within a discipline provide focus for relevance. According to Brunkhorst (1991) integration of science disciplines enables students to form an authentic picture of science as it is practiced in the real world.

Rutherford and Ahlgren (1990) suggest that the concept of environment is a natural organizing principle for the teaching of science content due to its close relationship to real-world problems. Environmental science concepts are well suited to exploration and comprehension through an integrative approach since the complex nature of such concepts cannot be internalized without repositioning knowledge within the context of several discipline areas (Howe, 1995).

Support for the use of an interdisciplinary approach to teaching environmental science is illustrated in the Washington State Board of Education's response to RCW 28A.230.020. The Board passed a resolution requiring that environmental education be taught at all grade levels, using an interdisciplinary emphasis for instruction (1990).

Of the myriad of issues related to the environment Orr (1994) believes goals should be set so that the study of water is central to the curriculum. He purports that water studies should be implemented in all school curriculum due to the crucial importance of water to human survival and the fundamental need to create a sense of stewardship for this valuable resource.

Roth (cited in Saveland, 1976), specifies particular concepts that are significant for inclusion in environmental education programs. The list of concepts was formulated after a panel of 67 academicians screened and evaluated 350 responses from 24 universities and 40 disciplines. The resulting 111 concepts were placed into categories and rated as to whether each concepts was essential, highly desirable, desirable, satisfactory, or unacceptable.

The following five water related concepts were included in the final list. Items one through four were rated as highly desirable and item five was rated as desirable:

1. Water supplies, both in quantity and quality are important to all levels of living
2. Water is a reusable and transient resource, but the available quantity may be reduced or quality impaired
3. The earth and life on it are greatly affected by the atmosphere
4. As populations increase competition for the use of water increases resulting in a need for establishing water use priorities
5. The amount of precipitation that becomes available for use by man varies with topography, land use, and applied management practices. (pp. 5-26)

In reviewing age appropriate content objectives in environmental education Doraiswami, Biabas, Saveland and Walls (cited in Saveland, 1976) suggest adolescents be familiar with water concepts such as the water cycle, understanding the distribution of water on earth and its scarcity, recognizing the influence of pollution, and investigating decisions relating to the quality of water.

An important principle of environmental education programs involves the inclusion of activities that occur beyond the classroom, activities that place students in authentic environmental situations (Saveland, 1976; Orr, 1994). According to Emery, Davey and Milne (cited in Saveland, 1976) opportunity for student inquiry and higher order thinking increases with exposure to field activities where concepts are learned in conjunction with process skills such as observation, data collection, and measurement.

Summary

Research and literature reviewed in chapter two of this study supported the development and delivery of integrated curriculum for middle school students. Separate subject curriculum, typically utilized in the middle school setting, limits the cognitive and social needs of young adolescents. Integrated curriculum connects subject areas providing a filter through which to examine knowledge and gain facility with key questions and issues.

In the literature reviewed, researchers suggested that student motivation and retention of information improved with the use of integrated curriculum. One method for integration was to connect mathematics and science, since the disciplines are closely related. The natural connection between these two subjects lessens the abstract qualities of both fields of study. Researchers also suggested that environmental concepts are well suited to an integrative approach and that the study of water related concepts should be explored due to the significance of water as a crucial resource.

CHAPTER 3

PROCEDURE

Introduction

The purpose of this project was to develop an interdisciplinary curriculum correlating the environmental issue of water quality with the disciplines of physical science and mathematics.

This chapter contains background information detailing:

1) Analysis of current state and local curriculum requirements
2) Process utilized to develop the project

Analysis of Current Local and State Requirements

In the Yakima, Washington Public School District, sixth grade middle school instruction includes, but is not limited to, the study of physical science and mathematics. In alignment with the Washington State Commission's draft proposal on Student Learnings in science and the Yakima Public School District Course Outcomes and Exit Outcomes for the sixth grade, the following broad curriculum goals are addressed in the study:

1. Identify environmental issues related to physical science, design and conduct a project to improve the environment
2. Understand science as a process and apply the scientific method to a given situation
3. Integrate science with other disciplines to form a

conclusion or solve a problem

4. Apply knowledge of the content areas and problem solving skills to current affairs and real-life situations in society
5. Use process skills of problem-solving, communication, decision-making and accountability

The Process Used to Develop the Project

To obtain background information on integrated curriculum development a review of related literature was conducted. As a result Jacob's (1989) four step process for the development of interdisciplinary curriculum was implemented. The resulting curriculum design was analyzed using Beane's (1992) criteria for success.

Step one in the development of the project was the selection of an organizing principle that took into consideration the interests and characteristics of sixth grade middle school students.

Step two was the identification of mathematics and physical science course outcomes for the Yakima Public School District, and water quality principles related the organizing principle. Environmental science concepts were evaluated for pertinence according to Roth, Doraiswami, Biabas, Saveland and Walls (cited in Saveland, 1976). Several science, mathematics and environmental education texts and resources were also used as references.

Step three of the project was establishment of general curriculum goals and the essential questions emerging from those goals. The essential questions provided a framework for the scope and sequence of the remainder of the project. Key outcomes related to each essential question were established and correlated with specific subject area content.

The fourth step of the project was researching and designing individual lessons, laboratory activities, and field activities that related to the essential questions and pertinent concepts.

After developing the lessons, laboratory activities, and field activities, the project was evaluated according to Beane's (1992, p.39) criteria for success. Of Beane's criteria the following were addressed in the development of the project:

1. The project involved a concern that was widely shared by young adolescents and involved a larger socially significant issue
2. The project had the potential to engage a wide range of knowledge and resources, and posed opportunities for in-depth work
3. The project presented possibilities for a wide range of activities
4. The project presented possibilities for social action

Methods for evaluating the effectiveness of the project study include personal portfolios kept by students, objective tests, final projects and presentations made by students.

Chapter 4

THE PROJECT

Introduction

This interdisciplinary curriculum was designed to help dissolve the boundaries between separate subject content so that students can gain a deeper understanding of related concepts by encountering them in relevant and connected ways. The specific activities presented are also designed for students to gain proficiency in research, writing, reading, communication, and experimentation through the use of hands-on performances.

A scope and sequence for integrative opportunities in mathematics, physical science and water quality is presented. The extent to which these materials lend themselves to a cohesive learning experience will depend on the unique and specific needs of individual educators and adjustments will need to be made accordingly.

Explanation of the Project

The C.R.E.E.K. project, *choice and responsibility for environmentally educated kids*, is the organizing principle for this interdisciplinary curriculum. General goals were established and from these general goals three essential questions were constructed. The essential questions provide the basis for the scope and sequence of the curriculum. Key outcomes related to each essential question were developed as well as specific subject area content integration. This project will include the following:

1. Frameworks illustrating the relationship between the organizing principle, general goals, essential questions, key outcomes, and content integration
2. Sample lesson plans

Student Expectations

Many of the projects that are initiated in this curriculum are accomplished within cooperative student groups. Extensive instruction according to the guidelines of cooperative group theory is strongly advised prior to the initiation of the curriculum.

Student competencies resulting from involvement with this project are assessed according to the following:

1. Anecdotal observations of student performances such as the application of knowledge in response to a task
2. Observation of student products such as learning logs, journals, and project pieces
3. Use of classroom measurements such as teacher made tests

Unit Requirements

It is important to note that the length of time required to implement the activities presented can vary from several days to several weeks. Activities included in this project represent a sample of the many lessons required to fully implement this interdisciplinary curriculum. In some cases lessons introducing specific concepts are necessary prior to the introduction of an activity.

CHOICE AND

RESPONSIBILITY FOR

ENVIRONMENTALLY

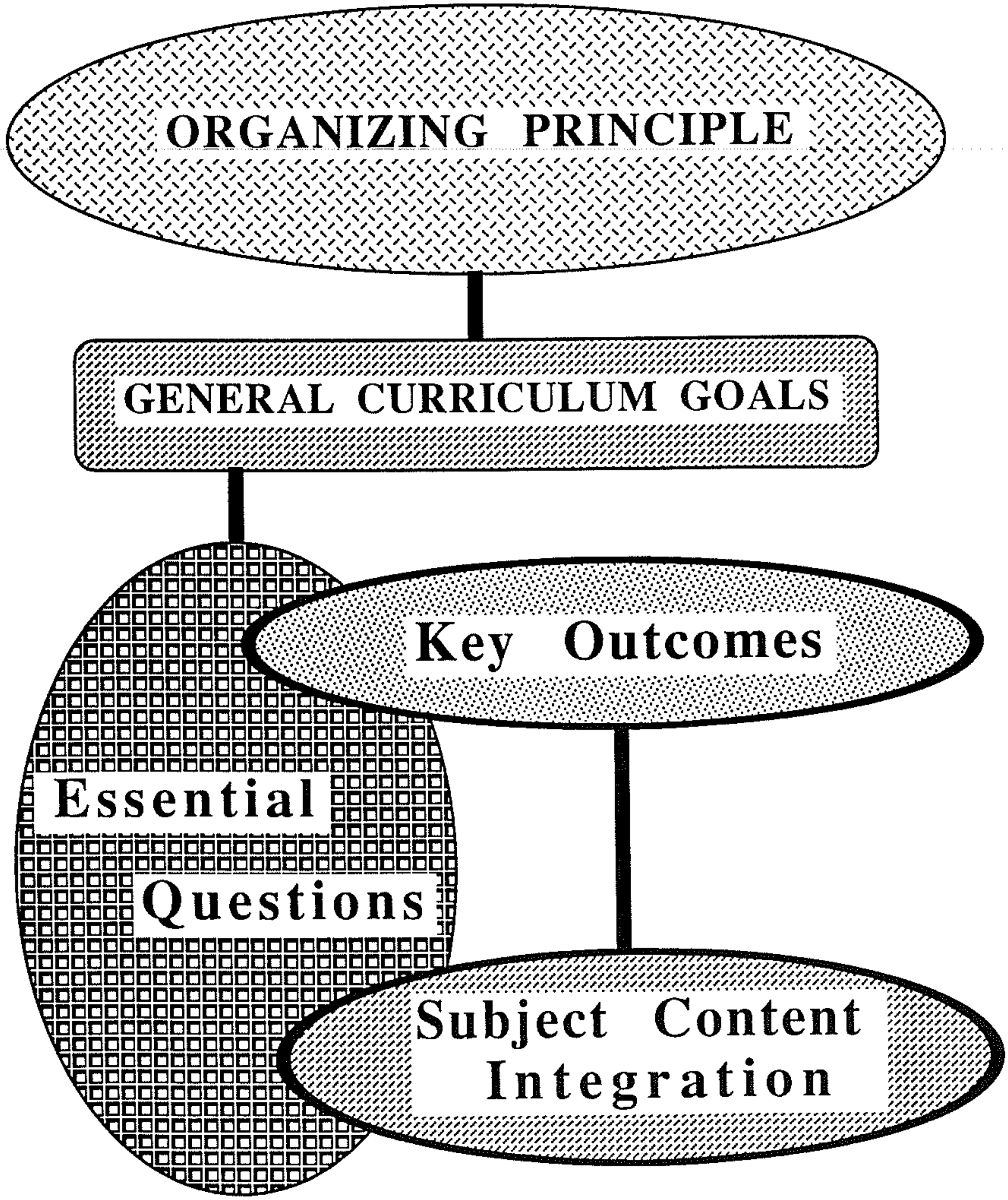
EDUCATED

KIDS

An Interdisciplinary Water Quality Curriculum for 6th Grade

TABLE OF CONTENTS

INTERDISCIPLINARY PROJECT ORGANIZATION



Organizing Principle

C. R. E. E. K

Choice and Responsibility for Environmentally Educated Kids

General Goals

1. Understand water as important to life

2. Understand that the distribution of fresh water resources are limited

3. Understand water as a transient resource

4. Understand that competition for the use of limited water results in a need to establish conservation practices

5. Understand that the quality ofwater may be impaired by human caused pollution

6. Understand that the influence of pollution results in a need to establish decisions relating to the quality of water

Essential Questions

1. Why is water precious and how does it get around?

2. Waste not, want not: In what ways can water be used efficiently?

3. What are water pollution problems and what can be done about them?

Essential Question #1

Why is water precious and how does it get around?

KEY OUTCOMES

A. Compare and contrast water resources
B. Describe physical and chemical characteristics of water
C. Investigate the main features of a watershed

Essential Question # 2

Waste not want not! In what ways can water be used efficiently?

KEY OUTCOMES

A. Understand water as a common resource shared by all water users
B. Analyze community water issues

Essential Question # 3

What are water pollution problems and what can be done about them?

KEY OUTCOMES

A. Learn how to conduct tests to determine the quality of water
B. Monitor water quality on a local river, creek or stream

Essential Question # 1: Why is water precious and where does it come from?

Key Outcome A

Compare and contrast water resources

Math: Averaging, estimation, percentage, graphing

Science: Water as essential for all living organisms, water distribution on earth

Environmental Education: Water as a part of culture, limited availability of fresh water on earth

SAMPLE ACTIVITIES:
(**M**= math **S**= science **EE**= environmental education)

	Activity	M	S	EE
1.	Investigate water in our language (see sample lesson "Investigating water words")	√		√
2.	Investigate water related ceremonies in different cultures			√
3.	Calculate the percentage of fresh water available for human use. (See sample lesson "Precious percents")	√	√	√
4.	Calculate and graph the percent and weight of water in our bodies and various body organs	√	√	√
5.	Calculate the amount of water in foods we eat and in a typical meal	√	√	√

Essential Question # 1: Why is water precious and where does it come from?

Key Outcome B
Describe physical and chemical characteristics of water

Math: Graphing, measurement, ratios

Science: Scientific method, phases of water, phase changes of water, hydrologic cycle, solutions, solubility, saturation, surface tension, mixtures, kinetic energy

Environmental Education: Water cycle is central to earths natural systems

SAMPLE ACTIVITIES: (**M**= math **S**= science **EE**= environmental education)	**M**	**S**	**EE**
1. Discover liquids expand when heated and contract when cooled		√	√
2. Discover water is an exception to the rule of expansion and contraction		√	√
3. Observe heat as the energy of moving molecules	√	√	
4. Create a model of the hydrologic cycle (See sample lesson "Water Worlds")	√	√	√
5. Calculate the effect of heat energy on phases of water	√	√	
6. Conduct and experiment to test the relationship between evaporation and surface area (See "Additional demonstrations and experiments")	√	√	√

SAMPLE ACTIVITIES: (Continued)
(**M**= math **S**= science **EE**= environmental education)

		M	S	EE
7.	Conduct an experiment to test evaporation rates and humidity (See "Additional demonstrations and experiments")	√	√	√
8.	Conduct a discovery lab investigating density of liquids	√	√	
9.	Design and conduct an experiment to demonstrate how heat and salinity effect the density of water	√	√	√

Essential Question # 1: Why is water precious and where does it come from?

Key Outcome C
Investigate the main features of a watershed

Math: Volume, mass, area, scale, coordinate graphing, ratios

Science: Density, permeability, groundwater, surface water, aquifer, water table, source, parts of a watershed, gravity, hydrologic cycle

Environmental Education: Water cycle is central to earths natural systems
Learn basic groundwater principles
Relate to different land use practices and groundwater contamination

SAMPLE ACTIVITIES: (M= math S= science EE= environmental education)	**M**	**S**	**EE**
1. Demonstrate that the ground can hold water	√	√	
2. Compare and contrast the movement of water through different soil materials		√	√
3. Create and analyze a mini aquifer		√	√
4. Investigate the integral relationship between surface water and groundwater		√	√
5. Build a watershed model and analyze the effects of land use variations on runoff	√	√	√
6. Identify and map the watershed in which your school is located	√	√	√

Essential Question # 2: Waste not, Want not! In what ways can water be used efficiently?

Key Outcome A

Understand water as a common resource shared by all water users

Math: Volume, graphing, percentage

Environmental Education: Establish environmentally responsible behavior, gain knowledge of water use practices and conservation strategies

SAMPLE ACTIVITIES: (M= math S= science EE= environmental education)	**M**	**S**	**EE**
1. Illustrate ways in which water quantity is threatened by water wasting habits			√
2. Calculate the average amount of water wasted from a leaking faucet	√		√
3. Investigate direct and indirect uses of water			√
4. Monitor, chart, and graph daily water use (See sample lesson "W.A.T.E.R. : Weigh all the environmental reasons)	√		√
5. Identify positive conservation practices and illustrate how they save water	√		√

Essential Question # 2: Waste not, Want not! In what ways can water be used efficiently?

Key Outcome B

Analyze community water issues

Math: Decimals, averaging, graphing, volume, surface area

Science: Precipitation, evaporation, saturation, distillation, condensation, gravity flow, transpiration

Environmental Education: Environmentally responsible behaviors, water as a finite resource

SAMPLE ACTIVITIES: (M= math S= science EE= environmental education)	**M**	**S**	**EE**
1. Analyze average local precipitation patterns	√	√	√
2. Analyze average local evaporation rates	√	√	√
3. Build a model of your community water delivery system		√	√
4. Demonstrate purifying water by distillation		√	√
5. Demonstrate how water treatment plants purify water		√	√
6. Visit the local water treatment plant		√	√
7. Design a community service project related to water conservation (See Sample lesson "Tuna-Can Conservation")	√	√	√

Essential Question # 3: What are water pollution problems and what can be done about them?

Key Outcome A

Learn how to conduct tests to determine the quality of water

Science: Atomic structure, periodic table of elements, chemical reactions, chemical change, acids and bases, pH, dissolved oxygen, nitrates, phosphates, fecal coliform, riparian zone habitat

Environmental Education: Develop skills and knowledge in helping to maintain and improve water quality
Understand indicators of and impacts on environment water quality

SAMPLE ACTIVITIES:
(**M**= math **S**= science **EE**= environmental education)

	Activity	M	S	EE
1.	Create a Bohr models of atoms		√	
2.	Classify elements using the periodic table of elements and investigate chemical symbols		√	
3.	Investigate chemical reactions in a discovery lab		√	
4.	Investigate acids and bases in a discovery lab		√	
5.	Understand the meaning of important tests for measuring water quality (See sample lesson: Testing the waters)		√	√
6.	Become familiar with human impacts on water quality (See sample lesson "Testing the waters")		√	√

Essential Question # 3: What are water pollution problems and what can be done about them?

Key Outcome B

Monitor water quality on a nearby river, creek, or stream

Math: Measurement, volume, rates, velocity, charting

Science: Discharge, riparian zone habitat

Environmental Education: Develop skills and knowledge in helping to maintain and improve water quality
Recognize indicators of and impacts on environmental water quality

SAMPLE ACTIVITIES:
(**M**= math **S**= science **EE**= environmental education)

		M	S	EE
1.	Conduct a dry lab simulation of water quality testing and analyze the results (See sample lesson "pollution Solutions")	√	√	√
2.	Determine velocity and volume of the water at the field location	√	√	
3.	Conduct a stream survey at the field location	√	√	
4.	Conduct water quality tests at different points at the testing location		√	
5.	Analyze and communicate the results of the water quality tests		√	√
6.	Create a fieldtrip guide describing the testing location, land use practices, any issues or concerns, and courses of action taken		√	√

INVESTIGATING WATER WORDS

Essential Question #1 Key Outcome A

Connection: Water Quality/Mathematics

OBJECTIVE:
Appreciate the extent to which water related words are part of our language
Calculate averages

MATERIALS:
construction paper
marking pens or colored pencils
scissors

CUE SET: Have a song such as "Raindrops keep falling on my head" playing as students enter the room and display one or two books that have water related titles such as 10,000 Leagues under the Sea. Have the common phrase "It is raining cats and dogs" written on the chalkboard.

LESSON:

1. Using the cue set lead a discussion of the abundance of water related words in our language. Discuss the importance of these words.

2. Assemble students In groups of 3-4. Assign the following cooperative group work jobs: recorder, reporter, facilitator, time keeper.

3. Each group will brainstorm a list of all the words they can think of

that relate directly to water and the recorder writes them all down. For example, cloud, river, ice, dewdrop, frost, glacier, iceberg, etc. Ask each group to estimate the number of responses they can generate during a time limit of about 7-9 minutes. Conduct the brainstorming. (Students are encouraged to use examples already shared)

4. Stop after 7-9 minutes. One at a time each reporter announces the total number of responses for their group. List figures on the chalkboard. Ask the question:

"How could we figure out the average number of responses each group created during that time?"

5. Lead a discussion and generate the formula:

Add all group totals and divide by the number of groups participating. This equals the average number of responses for a group in the allotted time.

Examine how close each group came to their prediction.

6. One at a time each reporter calls out a water word that is on their list. If any other groups have the same word on their list they must omit that word from their list by crossing it off. Each group takes turns reporting water words until all words have been accounted for.

7. Using construction paper, marking pens and scissors, students cut out various size water drop shapes and write a water related word

on each drop until they have done so for each word still on their list.

8. Conduct the same process for creating book titles, song titles, and phrases that relate to water words.

9. Completed drops can be displayed in a number of ways. For example, the drops can be attached to strings that descend from a large tag-board faucet and "tent" out across the room. Groups can create cloud shapes from construction paper and hang their drops from this or they can simply be posted around the room.

CLOSURE:

1. Each group shares their most "whacky" water word.
2. Estimate the total number of water words in the room.
3. Question: Why do you think there are so many water related words in our language?

PRECIOUS PERCENTS

Essential Question #1 Key Outcome A

Connections: Water Quality/Mathematics/Physical Science

OBJECTIVE(S) :

Understand the limited amount of fresh water on the earth
Graphing
percentage

MATERIALS:

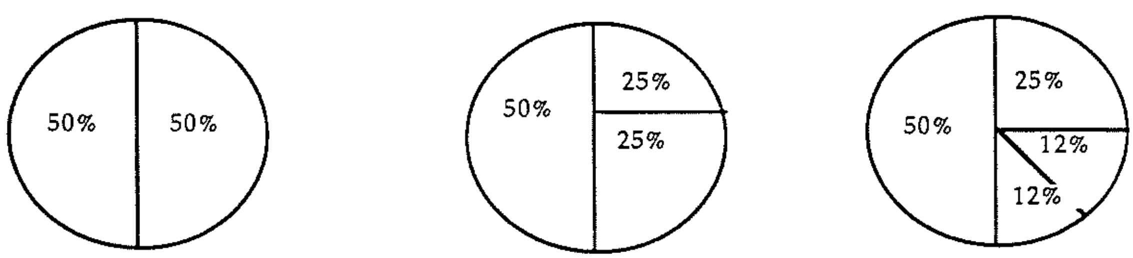
Handout ***Where in the World is All the Water?*** - one for each student
Handout ***Precious Percents of Our Liquid Landscape*** - One for each student
5 - one gallon containers
Large transparent container (6 gal. capacity)
3 - 250 mL beakers

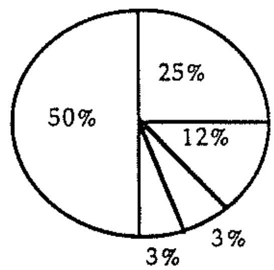
CUE SET: ***Did you know that there are living organisms which can exist without air but no known organisms can live without water?***

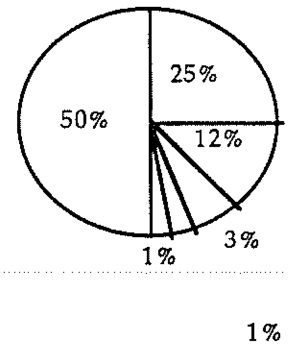
LESSON:

1. Read and discuss the handout Where in the World is All the Water.

2. Explain that percent means out of one whole or out of 100. Draw a circle on the chalkboard, divide it in half and elicit from students what percent one half would represent (50%). Draw another circle, divide it in half, write 50 % in one half and divide the remaining half in half. Elicit from students what this amount would represent (25%). Repeat this same process each time dividing by one half until you have completed the following diagram.







3. To increase understanding about percentages discuss the following:

a. What number would represent 50% if there were 100 students in the classroom? (50). What math did you do to arrive at the answer? (divided by 2).

b. What is the total number of people in this room?

c. If about half of the people in this room had a glass of water to drink what percent would that be? (50%) What number would that be?

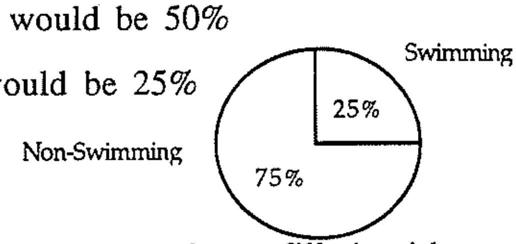
d. What math did you use to arrive at an answer? (Divided the total number of students by 2).

4. Students work in pairs writing math examples, similar to the one above, relating to water which represents 25% and 75%. Share selected examples and ask for volunteers to diagram and explain their work on the chalkboard.

Example: 200 students went to a class party but only 50 went swimming. (25%)

200 divided by 2 = 100 which would be 50%

100 divided by 2 = 50 which would be 25%



5. Conduct the following demonstration:
Select a student to pour 5 pre-filled one gallon containers filled with water into the large clear container. (Recycled gallon milk jugs are easy to obtain and easy for students to handle).

Q: Imagine that this water represents all the water on earth. (Recall) How much do you think represents fresh water? (From Handout)

97% of all the water on earth is salt water

2% is all the water frozen in polar ice caps and glaciers

1% is available for our use

$2\% + 1\% = 3\%$

Q: Predict what part of the large container of water would represent 3%,

Measure out two and one-half cups of water into beaker #1
(This represents 3% of the 5 gallons = all the fresh water in the world.)
From beaker #1 measure 3/4 cup of water and pour into beaker # 2.

(Beaker #2 represents the total amount of fresh water= 1% available for drinking and other uses.)

(What is left in beaker #1 = 2% of the total water. This represents the amount of fresh water frozen in polar ice caps.)

Q: What type of water is left in the large container? (97% saltwater)

Q: (recall) List some of the common uses for water other than for drinking. (For example, washing, recreation, agriculture, transportation of goods, power)

Q: (comprehension) Where specifically do you find fresh water? Does it look clean and drinkable? Answers will vary.

6. Students work independently on handout, *Precious Percents of our Liquid Landscape.*

CLOSURE: Discussion questions

1. In what ways is water important to our lives?

2. What is meant by the statement that water is scarce

WHERE IN THE WORLD IS ALL THE WATER?

Water makes up about 65 % of our bodies. Humans, and all other animals as well as plants, require water to live; without it, we would be able to last less than a week.

Water is an important part of our lives in many different ways. When it rains water helps keep the air clean. Water helps keep our cities and our bodies clean too. Water is a necessary part of living. Water is used for growing crops, for shipping manufactured goods and for the transportation of people also. We swim in it and use its power to make electricity. In some places rivers creeks or stream form the boundary between cities or states. Water even enriches our language.

WATER: A LIMITED RESOURCE

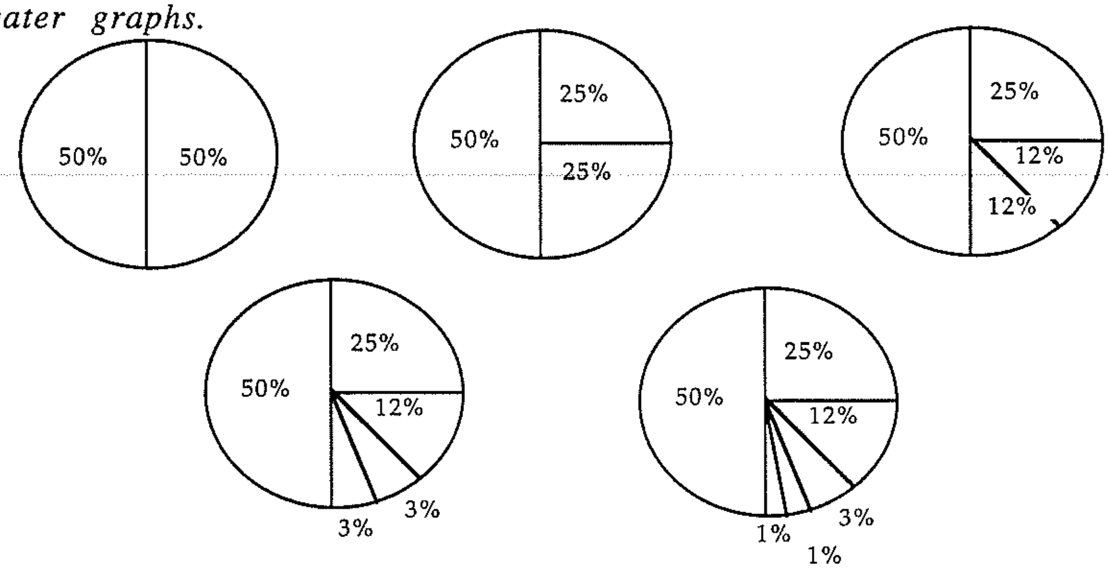
Water seems to be all over the earth. As a matter of fact more than 70% of the earth's surface is covered by water. Why then is it true that most of the water on earth is difficult to use? Careful inspection shows that most of the earth's water is difficult for us to use because about 97% of it is salty ocean water! While this is great for floating and boating it is a bit harder to process for more useful purposes like drinking.

Only 3% of all the water on earth is fresh. Fresh water is not very abundant but it can be found in many different places including, lakes, streams, rivers, glaciers and polar ice sheets. Of all the freshwater on earth 2% is frozen in glaciers and polar ice sheets. That leaves a fragile 1% of the total amount of water on our earth for us to use and most of that water is found underground!

PRECIOUS PERCENTS OF OUR LIQUID LANDSCAPE

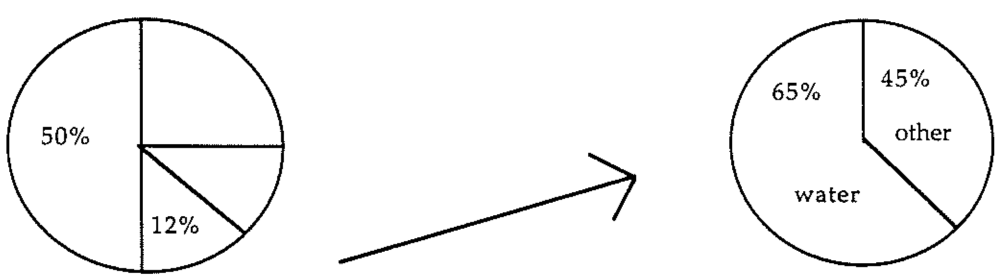
Name ______________________________ Date ____________________

Study the diagrams below, then follow the directions for creating water graphs.



Use the information from the handout *WHERE IN THE WORLD IS ALL THE WATER* to create circle graphs on the back of this paper for each of the following. Label each of your graphs ! Number one is done for you below.

1. The percent of our total body that is made up of water.
2. The percent of the total earth's **surface** that is covered with water.
3. The percent of the earth's **water** that is salty.
4. The percent of the earth's **water** that is fresh.
5. A combined graph that shows the percent of the earth's **water** that is salty, fresh and locked in glaciers and polar ice caps, and fresh for our use.



50% + 12% = 62% Very close to 65%

Total Body

WATER-WORLDS

Essential Question #1 Key Outcome B

Connections: Water Quality/Physical Science/Mathematics

OBJECTIVES:

Describe particle orientation in the liquid, solid, and gas phases of matter
Recognize three phase changes of matter
Recognize heat as a form of energy
Make a model of and explain the steps of the hydrologic cycle
Recognize the finite availability of water on earth
Measure in metric units of volume
Construct a chart and line graphs from data collected

In this discovery based lesson students make observations of the hydrologic cycle as jars of water are positioned in different environmental situations before formal use of terms or introduction to the concepts. Have students begin bringing in clean jars with labels removed several weeks in advance of this lab activity. Pairs of jars must have the same diameter mouth. Suggestions include small jam jars, small mayonnaise and pickle jars, small peanut butter jars, baby food jars, etc.

Three locations for placement of the jars should be decided upon in advance to accommodate the following conditions:

1. The first location must provides sufficient heat to produce evaporation, condensation and precipitation in the jars. Suggestions include placing jars on or near heating vents, on a sunny window sill, or under an infrared light.

2. The second location must be a cooler environment, away from a direct heat or light source. The goal is for evidence of condensed

water vapor on the sides and tops of the jars from location 1 to disappear.

3. The third location should also create some degree of the conditions for evaporation, condensation and/or precipitation as experienced in location 1.

Careful consideration for safety needs to be made when considering placement of the jars (especially if they are being placed outside the classroom).

MATERIALS:

For each student:

The Hydrologic Cycle - Handout
Water-World Summary and Evaluation - Handout

For each group of 2-4 students:

Handout- Lab sheet ***Water-world***
Two jars Masking tape
3x5 index cards for labeling
Permanent ink marker
1- Graduated cylinder
1- Small dark rock
1- 12 x 18 sheet of construction paper
6- water-world log sheets
1- card thermometer

LESSON:

Water-world lab activity. Students should be divided into groups of 2-4. Distribute one copy of the lab activity sheet to each group.

1. Review lab activity directions together. Reinforce the need for

carefully reading the volume of the liquid in the graduated cylinder at eye level by introducing the concept of meniscus.

2. Emphasize careful and secure taping of the two jars.

3. When all groups have finished instruct students that they will be making careful qualitative and quantitative observations of their jars over the next few days and that the location of the jars will change periodically.

4. Guide students in brainstorming types of observations that will be made, emphasizing how observations can be quantified. List all ideas on the chalkboard. Some suggestions may include:

*Changes in the water level, quantified in millimeters or centimeters.
*Time of the observation, quantified in hours and minutes.
*Jar location.
*Conditions at each location i.e. sunny, shady, warm, cold.
*Temperature, quantified in degrees Celsius.

PLEASE NOTE: Students may suggest observations that include phase changes of the water. If this occurs list any predictions suggested by students, however since this is a discovery based activity all ideas should be accepted and the teacher should not provide any particular guidance or explanation at this point.

5. Tell students that their observations will begin the following day and they will need to include a diagram of their jar and it's contents

as part of each daily observation. Using an overhead transparency of the Water-World Log, demonstrate the need for accurate and neat record keeping.

6. Handout a copy of the log sheet. Groups fill out the first log sheet and place their jars in the first location. Give each group a 12 x18 sheet of construction paper to fold in half and label and decorate as a cover for their daily observation logs.

7. Each day student groups will complete one water-world observations log. Water-world jars should remain at each location for two observations, that is, two days. A total of 6 observations will be made

APPROXIMATELY 6 DAYS LATER (AFTER ALL OBSERVATIONS HAVE BEEN MADE)

1. Using the information gathered on the observations log, instruct groups in the creation of a data table that includes the following:

   Date
   Water level in millimeters
   Temperature in degrees Celsius

2. Instruct each group to include the following two line graphs illustrating the information gathered from observations and organized in the data table:

   a. Line Graph one - show the change in temperature (measured in degrees Celsius), over time (measured in days).

   b. Line graph two - show the change in water level (measured in millimeters), over time (measured in days).

2. After students have completed the water-world data table, and line graphs facilitate a class discussion of the observations made at each location and the information presented in the line graphs. Record responses. If not specifically mentioned the following should have occurred:

* The water level in the jar decreased when the temperature increased.
* The water level in the jar increased when the temperature decreased
* Water formed on the sides and on the top of the jar when the temperature increased
* Water droplets formed at the top of the jar when the temperature increased.
* Water on the sides and top of the jar decreased when the temperature decreased.

*** It is crucial to note that expected results may differ from actual results. This should be considered a teachable moment. It is important to validate observations by proposing suggestions that could explain the differences in expected results.**

3. Distribute and read handout, The Hydrologic Cycle. Compare the diagram of the hydrologic cycle on the handout with the observations made of the water-world jar.

4. Examine the concept of matter as tiny particles that are always in motion and that heat energy causes particles to move faster and farther apart.

5. Examine the concept that matter exists in 3 main phases, solid,

liquid and gas, and provide an illustration of the particle arrangement for each phase. Discuss phases of matter in the hydrologic cycle.

13. Examine the concept that matter can change from one phase to another as heat energy is either gained or lost. Describe the four main phase changes, evaporation, condensation, melting and freezing. Provide an illustration to show the particle arrangement as matter changes phase. Highlight where heat energy is gained and where it is lost. Discuss the process of phase change as it occurs in the hydrologic cycle.

NOTE: Some confusion may occur over the phase change of condensation, and the process of precipitation. The following is a simplified explanation.

Precipitation is not considered a phase change but is closely linked to the phase change of condensation. As water vapor cools it condenses and begins to form clouds. When enough vapor has condensed into the liquid phase droplets may form and fall, or **precipitate**, from the sky. If the air temperature is cool enough when this happens the water may change phase and freeze into a solid as hail or snow.

14. Distribute the water-world summary and evaluation sheet to be completed by each student.

WATER-WORLD LAB ACTIVITY

GROUP MEMBER NAMES: **DATE:**

MATERIALS: For each group: Two clear jars, masking tape, a small rock, thermometer, a graduated cylinder, water, index card, marking pen.

PROCEDURE:

1. Place the rock in the bottom of one jar.

2. Measure a 10-20 ml of water in the graduated cylinder and pour into the jar.

Record the volume of water placed into the jar. Record in milliliters

Water volume = __________

3. Place the second jar upside down on the top of the first jar and tape the two jars together securely

4. Using a permanent marker draw a short line indicating the beginning water level in the bottom of the jar.

5. Tape the small card thermometer onto the outside of the jar so that it can be easily read without picking up the jar. Create a label for your experiment and tape it to the group water-world jar (be creative!)

WATER-WORLD OBSERVATIONS LOG

GROUP NAME:

DATE:

DESCRIBE LOCATION:

HOW LONG THERE:
(Recorded in Days)

TIME OF OBSERVATION:

TEMPERATURE :

CURRENT WATER LEVEL
(Recorded in millimeters) :

CHANGE IN WATER LEVEL
(Recorded in millimeters) :

1. Describe the physical appearance of the jar and the condition of the contents. Use the space to describe any changes you observe and include a diagram providing as much detail as you can.

2. If the contents of your jar have changed at all create a hypothesis that explains these changes. In other words, why do you think changes have occurred.

3. How accurately did your group predict any changes in the appearance of the contents of your jar from the last observation ?

3. What will be the location of your next observation?

4. Form a prediction about the appearance of the jar and it's contents for the next observation.

THE HYDROLOGIC CYCLE

Water is in constant motion. It flows in rivers, it disappears from ponds, creeks, and oceans only to reappear as clouds, fog, mist, rain, hail, or even snow. This process of movement and change is predictable and is repeated in the same way over and over again.

A process that is repeated in the same way is called a "cycle." The process of water changing phase, from a liquid to a gas or a solid and then to a liquid again is called the hydrologic cycle. The word hydro comes from the Greek word *hydor* which means water and the word *logia* which means to study. In this way the hydrologic cycle means the study the water cycle.

Water that falls as rain or snow and fills the rivers, lakes and seas is heated by the sun and evaporates back into the atmosphere as a gas called water vapor. When the air cools, the water vapor condenses to form clouds or fog and mist. Eventually the clouds precipitate, or release the water as liquid rain, or as solid snow or hail. The process then begins again and is repeated over and over.

The amount of water in the world has never changed, however, the location of it shifts as the hydrologic cycle is repeated. Some water precipitates (falls) on top of and into the ground and it can be stored for long periods of time, even hundreds of years. Water moves from place to place as it changes from a liquid to gas and back. The water that is here is simply recycled again and again. The water we drink today may be the same water that flowed into the Nile River in Cleopatra's time, or that the Greek inventor Ctesibius used in 270 B.C. to demonstate the Clepsydra, a water clock, or that the famous Italian astronomer Galileo Galilei observed in 1624 when writing about the physics of tides. the water we drink today may even be the same water that you washed the dishes with last year !

Name: **Date:**

WATER-WORLD ACTIVITY SUMMARY AND EVALUATION

1. Describe and illustrate how your water-world model demonstrated parts of the hydrologic cycle?

2. Would it make a difference if you placed the water-world jar in a dark cupboard? Explain your thinking.

3. Create a hypothesis for the purpose of the rock in the jar?

4. Describe what happens to the particles of water during the hydrologic cycle when there is a phase change of a liquid to a gas.

5. In the above phase change is heat energy gained or lost? Explain your answer.

6. What type of phase change is taking place when it snows?

7. In the above phase change is heat energy gained or lost? Explain your answer.

PERPLEXING PRECIPITATION PROBLEMS TO PONDER

The diameter of an average raindrop is between 0.5 and 3.0 millimeters.

1. In the space provided draw and label a line that is 3 millimeters long. Draw and label another that is about half the width of the first line.

2. Now, draw a raindrop over each line above so that the fattest part of the drop meets both ends of the line.

4. An average raindrop can fall at a speed of up to 7.6 meters every second. If the raindrop with a diameter of 3 millimeters (the first drawing) fell at a speed of 7 meters per second how fast would you expect a raindrop half that size (the second drawing) to fall? Explain how you arrived at your answer.

5. In the United States the heaviest average rainfall amounts, up to 70 inches a year, occur in the Southeast part of the country. What states might you expect to find in the Southeast, Florida or Kansas?

6. The heaviest average rainfall in the world occurs in northeast India. As much as 26 meters of rain has fallen there in one year. One meter is roughly 39 inches. How many inches are equal to 26 meters? Show your work

ADDITIONAL DEMONSTRATIONS AND ACTIVITIES
Essential Question # 1

1. ***Concept: Warm dry air can hold more water vapor than cold, moist air; consequently, the warmer and drier the air above the water the faster the water evaporates.***

Guide students in designing an experiment to test the concept. Highlight the importance for controlling variables in order to design a "fair test."

Suggestions include preparing identical containers of water and placing one in a warm dry room and one in a refrigerator. Dampened sponges or wet cloths can be substituted for the containers of water.

Science integration: Evaporation, scientific method, designing an experiment, controlling variables, "fair test,"

Mathematics integration: Keep data on the length of time, temperature, humidity, and degree of evaporation (either by sight or by measuring mass on a balance scale) and analyzing the information.

Water quality integration: Discuss the validity of watering lawns when it is raining and watering lawns during the morning, middle of the day or in the evening. Factors controlling climate, analysis of annual precipitation, and evaporation rates world wide as they relates to availability of fresh water.

2. ***Concept: The larger the surface, the more quickly evaporation will take place because more molecules can leave the water at one time.***

Place the equal amounts of water in a shallow dish and in a beaker. Allow to sit in a warm location for several days. Monitor the degree of evaporation by measuring the change in mass of the two containers.

Science integration: Evaporation

Mathematics integration: calculate surface area and volume, graphing.

3. *Concept: Compare the rate of evaporation of different liquids.*

Design an experiment to test the rate of evaporation of fresh water versus saltwater.

Science integration: Density of liquids and saturation point, distillation.

Mathematics integration: Measurement, evaluating ratios, dividing decimals.

Water Quality integration: Freshwater resources, desalinization.

4. *Concept: Ground water and surface water are connected.*

Pour about 5 inches of gravel into an empty small aquarium. Slope the gravel and then add water so that a pond is formed. Cover one end of the tubing with cheesecloth to prevent gravel from clogging the tube and simulate a well pump by inserting clear flexible tubing into the dry land and into the simulated water table.

Simulate pollution by placing several drops of food coloring into the pond water and begin siphoning water out.

Water Quality integration: Water table, effects of pollution in rivers, streams and ponds on ground water.

W.A.T.E.R.
Weigh All The Environmental Reasons: A Conservation Project

Essential Question #2 Key Outcome A

Connections: Water Quality/Mathematics

OBJECTIVES:

Investigate decisions related to water usage
Recognize the need for establishing water use priorities
Collect and Evaluate personal water usage data
Formulate a chart of collected data on personal water usage
Create and interpret a bar graph, line graph, pictograph, and a circle graph
Create reasonable suggestions for personal water conservation practices
Converting standard units of measure into metric measure

MATERIALS:

W.A.T.E.R. handout - (1) for each student
Water-logged handout - (3) for each student
Water-Use portfolio guideline handout - (1) for each student
12 x 18 piece of tag board - (1) for each student
Construction paper
Centimeter graph paper - (approx. 6) for each student)
Rulers
Colored pencils and/or markers
Calculator - can be shared

LESSON:

Cue Set: (Have a two liter bottle of water as a visual aid) ***On average people need at least 2 liters of water each day in order to survive.***

1. Read and discuss handout entitled *W.A.T.E.R. Weigh All The Environmental Reasons, CONSERVING WATER: WHAT'S THE USE?*

2. Ask students how many different ways water is used in their homes. Discuss possible methods for getting an accurate idea of how much water is used each day in their homes. Discuss the value in being aware of personal water use and the importance of conservation.

3. Introduce the water usage project. Instruct students that they will be asked to keep a careful log of how much water is used at home for three days and that the information will be analyzed by creating graphs of the information. Students will end up with a clear idea of how much water is being used as well as potential areas for conservation.

4. Students brainstorm ways in which accurate data collection could be managed for their family. A suggestion includes posting a record sheet in high use areas like bathrooms and kitchens. Family members can indicate the activity and the student can calculate the amount of water used at the end of the day. Another suggestion is to conduct a family meeting at the end of the day and record results from memory.

Pass out ***parent/guardian letter*** to be taken home.

5. Review the concept of averaging and discuss the importance of using average values for each water use activity. For example, for flushing the toilet the group needs to agree that 13 liters will be the figure everyone will use.

Ask students why they think figures are listed as averages? Elicit the concept of variability in water pressure, types and condition of fixtures, as well as variable amounts used by the different people for the same process, i.e. we don't all brush our teeth the same way.

6. The chart on the handout lists the average volume in gallons and in liters. Teach students how to convert standard volume measure in gallons into metric measure in liters using the formula:

1 gallon = 3.8 liters

Using the chart on the handout guide students in changing all standard volume measures in gallons into metric volume measures in liters. For consistency all volume amounts should be carried only to the first decimal point.

7. Distribute one ***water-logged*** record sheet to each student. Students are responsible for turning in one log sheet each day rather than all log sheets at the end of the third day. (This is done to encourage accurate and responsible reporting as well as allowing opportunity to troubleshoot difficulties).

8. Facilitate students brainstorming a list of water use activities they may encounter that are not already included on the chart. Ideas include drinks of water, water used to make juice from concentrate, water from leaky faucets etc. Students should come to consensus on average amounts for each new category.

It may be appropriate to have a few beakers or graduated cylinders available for students to visualize volume amounts in liters.

9. Bring this section of the activity to closure by discussing the following questions:

a. If the cost of water doubled do you think it would affect peoples water use? How?

b. In what way would you expect water use issues to be different in Seattle than in Yakima? (Substitute locals within the frame of reference of your students)

c. The average person uses 150 gallons of water each day. Since you will only be keeping track of the amount of water used at home do you think this figure will be different? Explain your thinking.

d. Based on your answer above, make an hypothesis for the amount of water your family will use in one day. Record your hypothesis.

During the time students are collecting water use data:

1. Introduce students to the following concepts:
   a. Coordinate graphing
   b. Bar graphs
   c. Line graphs
   d. Circle graphs
   e. Pictographs

It is important that sample graphs from a variety of sources are introduced and that students begin to understand different function for different types of graphs. Resources include mathematics texts, science texts, newspapers, magazines, journals, etc. It is critical that students have access to resources when involved with the graphing component of the portfolio.

The intent here is to introduce basic concepts that will be practiced in the context of graphing personal water use data. It is expected that the teacher will provide further instruction as teachable moments arise during the remainder of the exploration.

FOLLOWING THE THREE DAY DATA COLLECTION PERIOD

1. Introduce water use portfolio project. Read and discuss portfolio guidelines.

2. Each student should have three ***water-logged*** record sheets. Direct each students in the creation of a data table that shows:
   a. Daily totals for each category
   b. Three-day total for each category
   c. Total water use per day (combined categories)
   d. Three-day total water use (combined categories)

3. All students must finish the data table before beginning any other aspect of the portfolio. Parts of the introductory page must be completed after the graphs have been created and analyzed. The sequence of completion of other portfolio pieces is not significant and allows students some personal choice as well as the opportunity to exercise good decision making. Students begin working on the remainder of the water use portfolio items.

3. Components of the water use portfolio include:
   A. **Tag board cover** - Illustrated

   B. **Introduction page** - Introduces who the student is, what will be seen in the portfolio, explains what it means to conserve water, tells why it is important to be concerned about water conservation.

C. **Table of contents** - lists portfolio pieces by page number

D. **Seven graphs** - Each graph will include a brief explanation of the results. The seven graphs are as follows:

(3) Line graphs - each showing the change in water used over the three day period for the following categories:
Bathroom, Combined Kitchen Laundry, and other

(1) Bar graph- comparing the three-day total water use of each
category (The three-day total for the Bathroom category compared with the three-day total for the Kitchen, Laundry, Outdoor, and Other categories).

(1) Pictograph - Comparing the total amount of water used after all three days by four different students.

(1) Circle graph - Comparing the percentage of the three-day total water used by category.

PLEASE NOTE - The following procedure may be used in order to calculate percentages for the circle graph.

Category total divided by the overall total multiplied by 100 = the percent of the total.

Ex. If the three-day total for the Kitchen category was 115 liters and the overall total of water used for all categories was 452 liters the formula would yield:

115 divided by 452 = 0.2544 multiplied by 100 = 25.44 % (Round to 25 %)
Kitchen use = 25% of the total water used for three days.

<u>(1) Student choice graph.</u>

E. **Concluding remarks** - One page discussion of the overall results including highest water use activities, lowest use activities, and suggestions for personal conservation practices based on the information shown by the graphs.

4. Students are asked to create a rough draft for each item in the portfolio. The project overview sheet is designed as a check off list so that rough drafts can be viewed for accuracy and misunderstandings can be caught early. It is desirable to identify students who have mastered particular component pieces and are willing to be "experts in their field" and provide assistance to others when asked. This frees the teacher with more time to view rough drafts or conduct mini-lessons when necessary.

Closure:

After completing the portfolios a class conference is held. Students organize into groups and compare results. Allow students to group according to:

a. Total Family size

b. Families with siblings under 5

c. Families with more boys than girls

d. Families with more girls than boys

As they group and re-group students should be looking for patterns in their data. Have groups report any interesting or surprising information.

WATER-LOGGED

Name ________________________________ Date

____

USE THIS PAPER TO KEEP A RECORD OF YOUR FAMILY'S WATER USE FOR ONE DAY. ORGANIZE THE INFORMATION IN THE FOLLOWING CATEGORIES:

BATHROOM (Flushing toilet, Shower, Bath, Brushing Teeth, Shaving, Washing hands and/or face)
KITCHEN (Dishwashing by hand, Dishwasher, Cooking, Cleaning, Water for pets, Personal consumption)
LAUNDRY (Clothes washing)
OUTDOORS (Washing cars, watering lawns and gardens)
OTHER

W.A.T.E.R. Weigh All The Environmental Reasons

CONSERVING WATER: WHAT'S THE USE?

Water is essential to all human life, we cannot survive without it. Most of the water we need is obtained from the food we eat, yet we commonly use much more water than the 2 liters that are necessary for survival. Between 1950 and 1975 the amount of water used per person in the United States increased by 50 percent, and the average person today uses about 150 gallons of water each day. So, what's the use? In other words, what is all that extra water being used for and is it necessary ?

Demand for water changes from place to place. In some areas there is high demand for water to irrigate crops and orchards, in other areas there is high demand for water for use in factories and manufacturing. In all communities there is demand for water for our personal use. Washing cars, watering lawns, flushing toilets, taking showers, washing clothes and dishes account for some of the personal uses for water, and as communities grow in size the demand for water keeps increasing.

So what is the big deal? Why bother about who uses how much water? As it turns out the issue is very serious. For one thing the amount of water in the world is limited and although the demand for water changes from place to place we all want water to be available when we need it. This means we have to be water-wise about how we use the water available to us so that we have what we want, when we want it.

During the 1970's an international event was observed called

Earth Day. The purpose of this event was to emphasize the importance for conserving the world's natural resources. Natural resources include things such as soil, water, plants, animals, and minerals. Some natural resources can be replenished, such as plants. Some natural resources cannot be replenished, such as water, and careful attention to the use and management of such resources is important so that we can maintain a healthy planet. Being actively involved in supporting a healthy planet is a responsibility that is at the center of conservation efforts.

This brings up the question of what individuals can do. Some people have shown that they can survive on less than a gallon of water a day and this includes what is necessary for cooking and washing. While this seems a bit drastic it certainly helps us to understand that we can reduce the amount of water we use without it being a huge sacrifice. The following table lists the average amount of water we use for different types of activities.

USE	VOLUME	USE	VOLUME
Shower	19 L per min.	washing hands	3 gal
Tub Bath	40 gal	washing car	570 L
Dish washing (by hand)	40 L	Garden hose	19 L per min.
Dishwasher	15 gal	Brushing teeth	
Washing machine	133 L	(tap running)	10gal
Toilet flushing	5 gal	(tap off)	2 L

**1 gal = 3.8 liters

O

WATER FACT

DID YOU KNOW THAT IN ONE YEAR, A VERY LEAKY TOILET CAN LOSE MORE THAN 22,000 GALLONS OF WATER?

Dear Parent or Guardian,

This letter is written to inform you that your student will be participating in a number of activities designed to increase awareness of the uses and abuses of water, and to encourage thoughtful decisions on habits of water use.

As part of the overall project your student has been asked to keep a record of water used at home by all family members for three days. Each day your student is required to complete a ***water-logged*** record sheet and return it to class. Suggestions have been discussed concerning how to encourage involvement by all family members in this process. I encourage you to discuss your student's plan and to provide any assistance you can to ensure successful and accurate data collection.

Please take a moment to review the particular water use activities your student will be recording and discuss any activities not on the list that might fit into the ***other*** category.

Sincerely,

Name ________________________ Date ____________

WATER USE PORTFOLIO PROJECT REQUIREMENTS

Wise water users know that they have a responsibility to care for water and they know how to save water every day. This portfolio project is designed help you ***catch the wave*** and become a wise water user. You will be creating a ***flood*** of water use information that will arranged as a portfolio or book.

Listed below are the five minimum requirements necessary for completion. It is important that you don't feel ***swamped*** so use your time wisely and remember to share all rough drafts with your teacher before you begin any final draft work. All final pieces must reflect your best effort and show special attention to detail.

MINIMUM REQUIREMENTS:

___ **COVER** - Be creative in preparing the cover of your portfolio. A catchy title and clever illustrations can generate excitement for the reader.

___ **TITLE PAGE** - This page gives your full name, the place and date of production, and copyright.

___ **TABLE OF CONTENTS** - lists portfolio pieces by page number

___ **INTRODUCTION PAGE** - Tell a little about yourself and what will be seen in the portfolio. Explain what it means to conserve water, and tell why it is important to be concerned about water conservation.

GRAPHS: Each graph must include a title and a brief explanation of the results. This can be included on the graph itself or on a separate page.

___ **LINE GRAPH** - showing the change in water used over the three day period for the BATHROOM

___ **LINE GRAPH** - showing the change in water used over the three day period for the KITCHEN.

___ **LINE GRAPH** - showing the change in water used over the three day period for the LAUNDRY.

___ **BAR GRAPH**- comparing the three-day total water used for KITCHEN, LAUNDRY, BATHROOM, OUTDOOR, and OTHER

___ **PICTOGRAPH**- Comparing the total amount of water used after all three days by four different students.

___ **CIRCLE GRAPH**- Comparing the percentage of the three-day total water used by category.

PLEASE NOTE - The following procedure may be used in order to calculate percentages for the circle graph.

(Individual category total) divided by (overall total) multiplied by (100) = the percent of the total water used by that category

___ **STUDENT CHOICE GRAPH**- Perhaps you discovered an interesting comparison to illustrate. Here is the chance to show the results.

___ **CONCLUDING REMARKS** - One page discussion of the overall results including highest water use activities, lowest use activities, and suggestions for personal conservation practices based on the information shown by the graphs.

TUNA CAN CONSERVATION KIT

Essential Question #2 Key Outcome B

Connections: Water Quality/Science/Mathematics

OBJECTIVES: Apply environmentally responsible behaviors in the development of a community service project aimed at teaching conservation methods to reduce water needed for watering lawns

MATERIALS:
Clean, empty tuna fish can
1 gallon clear container filled 3/4 with potting soil
Copies of the "pan evaporation" rate from the weather section of the newspaper each day for the previous week
Hundredths grid paper
Water
Cardboard
String
Glue Gun
Scissors
Tape

LESSON:

1. Involve students in a brainstorming discussion of various lawn watering practices in their community. Discuss questions of:

   a. How long should sprinklers be left on when watering?
   b. How often should lawns be watered?

2. To aid answering "How long should sprinklers be left on when watering?" discuss the following:

   a. The roots of most plants are in the top 12 inches of soil and the roots of most trees are in the top 18 inches. (diagram on the chalkboard).

   b. Necessary water for the health and maintenance of plants and trees need only be applied to the part of the soil where the roots are located. Any excess water soaks deeper into the soil and is wasted.

c. The amount of water needed to saturate soil depends on the type of soil and its permeability. In general, the soil types found in central Washington need one inch of water to soak 12 inches of soil.

3. Demonstrate one inch of water being applied to soil in the following way: Show students the clear container with soil. Affix a piece of tape on the container to indicate one inch above the top of the soil line. Apply one inch of water and observe as it soaks into the soil. Determine how much soil is being saturated in this example by measuring.

4. To aid answering "How often should lawns be watered?" discuss the following:

a. As the weather changes transpiration and evaporation rates will vary. Discuss the following scenarios in order to identify times of increased and decreased evaporation

* Several days of temperatures in the 90's.
* Several days of overcast skies and moderate temperatures.
* Several days of scattered rain showers and cool temperatures.

b. How often lawns need watering depends on how fast the water evaporates from the soil. One way to keep track of evaporation rates is to place a pan with one inch of water in a protected area outside. when the pan is dry it is time to water.

Another way to keep track of evaporation rates is by using information provided in local newspapers. Something called "Pan evaporation" is listed in the weather section of the newspaper every day. These evaporation rates are measured by a local government agency using very sensitive equipment. Keeping track of the evaporation rate each day from the newspaper until it reaches one inch is another method for knowing when to water.

Which method would be more accurate? Explain. Which method would be easier? Explain.

5. Pass out copies of the pan evaporation rates from local newspaper for the previous week.

* Students should notice that the rates are usually written in hundredths of an inch.

* Students should practice reading the evaporation rates using correct labels.

* Using "hundredths" grid paper student make a model of 0.17, and 0.33 in cooperative groups .

* Ask the question "If each hundredths grid equals one inch how much of one inch does 0.12 and 0.13 represent altogether?" (Answer: 0.50, "fifty hundredths" or one half of one inch).

* Have students calculate the amount of water evaporated for the week and determine if watering should have taken place.

PROJECT:

1. Discuss different types of sprinklers (have examples if possible) and how each use different amounts of water when in operation.

2. Show students the clean, empty tuna fish can. Students brainstorm ways in which the can could be used to measure water. If not discovered, reveal that the depth of the tuna can is approximately one inch.

3. Demonstrate that the can could be used for measuring evaporation of one inch of water.

4. Demonstrate that the can could be used for knowing when one inch of water has been applied to lawns by placing the can in the spray pattern of the sprinklers and timing how long it takes to fill

* This is how long an individual sprinkler needs to be in operation to saturate the one inch of soil necessary for healthy plant growth.

5. Introduce the idea of community service and explain that students will be making and distributing kits that teach how to conserve water when watering lawns.

6. Describe the kits as follows:

a. Each kit will contain two clean, empty tuna fish cans attached to a strip of cardboard.
b. A pamphlet will be attached that explains and illustrates:

*why it is important to conserve water
*how much water is necessary for lawns
*how to use the newspaper to know how often it is necessary to water lawns

7. Students begin collecting tuna fish cans. A school wide collection can be initiated by providing prizes for tuna cans turned in. Using a letter of introduction from the teacher, classroom students can petition local businesses to donate items such as candy treats, or coupons to be given as incentives.

8. Students are divided into cooperative groups in order to write and design the various components of the pamphlet, to cut 1-inch by 8-inch cardboard strips with a single hole punched in the top, and to cut 8-inch lengths of string.

9. Once pamphlets have been designed and copied, tuna cans collected, and cardboard cut, students assemble kits by hot gluing two tuna cans onto the cardboard and tying the pamphlet through the hole in the cardboard.

DISTRIBUTION:

1. Suggestions for distribution of kits include:
   * Local area arboretum
   * Presentations to other schools or classrooms
   * Community groups such as Lions club, Rotary, Women's Clubs, Boy Scouts, Campfire, Girl Scouts, etc.

TESTING THE WATERS

Essential Question #3 Key Outcome A

Connections: Water Quality/Physical Science

OBJECTIVES:

Understand the meaning and importance for conducting tests on water

MATERIALS:

Testing the waters handouts (one for each student)
How Do You Know?
Fecal coliform
pH
Dissolved Oxygen
Nitrates
Phosphates.
So, what did you find out?

LESSON:

1. Involve student in a discussion of the following concepts:

A. Many watersheds have been changed or altered as a result of growing demands by society. Review uses for water such as food, recreation, transportation, and manufactured goods. Give examples.

B. Increased demands placed on our waterways have resulted in the pollution of many of our streams, creeks, and rivers. Discuss any news related items.

C. Many factors can cause changes in the quality of a river and the changes that occur can vary from one period of time to another so it is important to conduct tests to evaluate the quality of water periodically.

2. Tell students that an organization called the National Sanitation Foundation has developed a method for testing water and determining its quality. Students will be learning about five tests that the National Sanitation Foundation considers as important for

understanding the health of a river, creek, or stream.

* Read handout - **How Do We Know?**

3. Arrange students in groups of five. Explain the following jigsaw reading activity:

* Each student in the group will receive a different informational handout describing one of five tests for water quality. This student will be responsible for teaching other members of the group about that test.

* Each student reads the information carefully before moving to a conference center. Each conference center (one for each of the five tests) is simply a place for all individuals responsible for a particular test to discuss that test, confirm their understanding and evaluate ways to teach it to their original group. For example, all individuals responsible for the phosphates test will get together to discuss that test.

* Students return to their original groups. Students take turns teaching about the information learned.

4. Following the jigsaw activity guide a large group discussion on the similarities and differences noted about the five tests. Give each student a copy of the **So, what did you find out?** evaluation questions to be completed. Students work cooperatively to answer questions.

Name ____________________ **Date** ______

HOW DO WE KNOW IF THE WATER IS CLEAN ENOUGH? WHO DECIDES?

One of the first questions a scientist asks when trying to determine if the water of a creek or stream is clean enough is ***what will the water be used for?***

Recreation: Swimming or boating

Agriculture: watering plants and/or animals

Industrial: cooling or cleaning machinery, steam production, transportation

Or

Will it be used as drinking water?

One way to measure or, *QUANTIFY,* the quality of water is by conducting different tests. When these tests are performed the results are analyzed and compared and this helps determine whether or not problems are occurring.

Many cities have their own pools for the public to swim in. How is it known if the water is clean enough for people to swim in? If you are thinking that water quality tests are conducted you are correct. As a matter of fact some, but not all, of the same tests that are conducted on rivers and streams are also conducted on city pools.

You may already be aware that the water quality of city pools are checked every day and in many cases several times a day. Why do you think this is done? Changes in the water can occur quickly and these shifts are part of a natural process that needs to be watched or ***monitored.***

This leads to another question scientists ask when considering how clean is the water is. The question is ***how often does the water need to be tested?*** The answer to the question of how often to test depends on many things. In general scientists recognize the need to keep track of the results of their tests over a period of time in order to look for patterns or trends in the information and this could mean testing daily or monthly or even yearly.

Name ________________ Date _____

TESTING THE WATERS: NITRATES

A. ***What does nitrates test for?***

Nitrogen (N) is a colorless, odorless, tasteless, nontoxic gas. About 79% of the element nitrogen is found as a gas in our atmosphere. Nitrogen is a necessary and important element for all plants and animals which need it for growth. Nitrogen that is in the gas phase cannot be used by most aquatic (water) plants and it must be changed into another state, a mineral state, in order to be useful. Nitrate, (NO_3^-) is an example of the mineral state of nitrogen. This water quality test measures the amount of nitrates present in the water.

B. ***What causes different nitrate levels in the water?***

As aquatic plants and animals die, bacteria disintegrate them and in the process nitrates are left behind. Organic waste material (anything that was once part of a living organism) can also be responsible for adding nitrates to water. As a result places where there are many animals can potentially be areas of concern. When the waste from the animals seeps into the ground water or travels directly into the water nitrate levels can rise.

Fertilizers are materials applied to plants or the soil to supply nutrients for improved growth. Some fertilizers are made from chemicals and other fertilizers are organic (once part of a living organism) such as manure. Either way most fertilizers contain nitrates and when the fertilizers get into the water the nitrate levels increase.

C. ***How do changes in nitrates effect water quality.***

Nitrates are a necessary element for all living plants and animals, however too much of it can cause problems. Nitrates help plants grow and if too much of it is present in the water it can cause plants to keep growing and growing and growing until there are too many plants. In this case the plants soon become over crowded and begin to die. As the plants die bacteria begin to decompose the dead material. In the process of decomposing the dead plants the bacteria use large amounts of oxygen from the water. Because of this oxygen use, the dissolved oxygen levels decrease and the amount of oxygen available for other organisms, like fish, is reduced. In this way the number of living organisms the water can support becomes limited. The quality of a river, creek or stream is determined by its ability to support many different organisms, such as fish, plants, insects, and other water organisms.

Nitrates that find their way in drinking water supplies are a serious health concern, especially for young children and infants. High levels of nitrates in the drinking water can cause illness and even death.

D. ***What human activities cause changes in nitrate levels of water.***

The main source for nitrates in the water, caused by humans, is when sewage gets into the water. This can happen in a number of ways.

If a wastewater treatment plant is not properly treating the water before it returns to the river nitrate levels can rise. If septic systems (underground waste water systems usually found in rural areas) are improperly located it can cause raw sewage to seep into the ground water.

Another way humans cause nitrates levels to increase is when too many fertilizers get into the water. Fertilizers are used by farmers to help grow healthy crops and in our cities to help keep our lawns and gardens healthy. If too many fertilizers are used they can travel with irrigation water back into a creek, river or stream. Fertilizer used in the city can runoff into storm drains and end up in rivers, creeks or streams also.

NAME ______________________ DATE _________

TESTING THE WATERS: DISSOLVED OXYGEN

A. ***What does dissolved oxygen test?***

A healthy creek or a river is one with a good environment for fish, aquatic plants, aquatic insects, and other organisms to live and grow. Oxygen is necessary for these aquatic plants and animals to survive. Some animals, like carp and catfish, can live in water that has very low levels of oxygen, but in order to support a wide variety of plants and animals there has to be plenty of oxygen. This is simply a test that determines how much oxygen there is in the water. Plenty of oxygen in the water is a good sign, however, if oxygen levels are low it could mean the water is polluted.

B. ***Where does dissolved oxygen in the water come from?***

Oxygen in the water comes from two main sources, the **atmosphere** and **aquatic plants.** Oxygen from the air gets into the water when waves tumble and the water mixes with air. Oxygen gets into the water from plants as they grow. In a process called photosynthesis all plants make food for energy and release oxygen in the process. If the plants are growing in the water (**aquatic plants**) the oxygen is dissolved into the water. Sunlight is necessary for plants to take part in photosynthesis.

C. ***What causes different levels of dissolved oxygen?.***

Certain conditions of the water make it easier for oxygen to mix in. Oxygen dissolves more easily in cooler water. Melting snow can make water temperatures cooler and can increases the amount of water flowing in a river. Increases in the amount of water flowing creates more places where the waves can tumble and churn, thus adding more oxygen. Increased water flow and cooler temperatures both increase the amount of oxygen in the water.

Since sunlight is necessary for photosynthesis to take place it is during sunlight hours that the level of oxygen in water will increase.

Organic waste is anything that was once part of a living animal or plant. When organic waste is in the water bacteria use up oxygen as the organic waste material is broken down. Oxygen levels can drop in a river or creek when there is a lot of organic waste for the bacteria to decompose. Sometimes decomposing bacteria use up the oxygen in the water faster than it can be replaced and plants and animals begin to die.

D. ***What human activities can change the amount of dissolved oxygen in water.***

Organic matter can get into a creek or river from food processing plants, sewage, meat packing plants, and dairy runoff. What is common to all of these process is that organic materials are added to the water and bacteria use up oxygen while decomposing the organic material. In addition fertilizers coming into the water from agricultural runoff or storm drain runoff cause the plant life to increase so rapidly that the water becomes choked with plants and soon the creek or stream cannot support all the plant life. As the plants die the waste is decomposed and oxygen is quickly depleted.

NAME ____________________ DATE __________

TESTING THE WATERS: FECAL COLIFORM

A. ***What does fecal coliform test?***

Fecal coliform is a bacteria that exist in the feces, or waste, of all warm-blooded animals. Fecal coliform bacteria are not harmful, as a matter of fact the bacteria helps us to digest our food. On the other hand, there are organisms coming from animals that are harmful and they are very difficult to test for. The harmful organisms travel into the water along with the fecal waste and the coliform bacteria. If the fecal coliform count is high that tells scientists that there is a greater chance that harmful organisms are also present.

B. ***What causes different fecal coliform levels in the water?***

Many cities have sewer systems that carry all wastewater to a treatment plant where it is cleaned before returning to the river. Sometimes when there is heavy rain sewer systems can become overburdened and waste material can empty over into nearby rivers or streams.

In rural areas sewage systems called septic tanks may develop leaks or be improperly constructed allowing fecal material to travel through the ground and eventually into the water.

In the city storm drains often carry rainwater and melted snow from city streets directly into rivers and creeks. Animal waste can be carried into the streams and rivers as they are washed down the storm drain systems when it rains.

C. *How do changes in fecal coliform effect water quality.*

Many scientists consider safe drinking water to have absolutely no sewage contamination, a zero fecal coliform count. Water with 100 to 200 fecal coliform bacteria in 100 milliliters of water is considered to be safe for skin contact like swimming. Water with fecal coliform levels above 200 per 100 milliliters of water however, should be avoided.

D. ***What human activities cause changes in the fecal coliform of water.***

Constructing illegal sewage connections can lead to contamination of rivers, creeks and streams. In addition cattle and other livestock that are permitted to wade into creeks and rivers for drinking water often contribute to high fecal coliform contamination .

NAME ____________________ DATE _____________

TESTING THE WATERS: PERCENT HYDROGEN IONS (pH)

A. ***What does pH test?***

Each molecule of water is made up of two hydrogen atoms and one oxygen atom. In any solution some of the water molecules break apart creating hydrogen ions (H+) and hydroxyl ions (HO-). A hydrogen ion is an atom of hydrogen that has given up its electron when the water molecule split apart (and as a result has a positive charge). An hydroxyl ion is made up of the other hydrogen atom and the oxygen atom. An hydroxyl ion has an extra electron taken from the hydrogen atom when the water molecule split apart (and as a result has a negative charge).

In any solution of water there will always be hydrogen ions and hydroxyl ions. The concentration of hydrogen ions in water determines the pH of the solution.

B. ***What causes different pH levels of water?***

pH is measured on a scale of 0-14. Pure water would have equal amounts of hydrogen ions and hydroxyl ion and would have a pH of 7 which is considered neutral.

1. The lower the hydrogen ion (H+) concentration the higher the pH number. Solutions in this category are called ***basic.***

2. The higher the hydrogen ion (H+) concentration the lower the pH number. Solutions in this category are called

3. The following is a pH scale.

← Acidic **Neutral** Basic →

0__1__2__3___4___5__6___7___8__9___10__11__12__13___14

← Adding hydrogen ions Adding hydroxyl ions →

H^+ OH^-

The following is a list of pH values for different common substances:

Normal rainfall -	5.5	Ammonia -	11.0
Lemon Juice-	2.0	Baking soda-	8.3
Milk-	6.8	Vinegar-	3.0
Tummy tablets	10.5	Cola-	4.0
Battery Acid	1.0	Bleach-	12.0

C. ***How do changes in pH effect water quality.***

Many plants and animals are sensitive to the pH level of water. Larger organism may not be harmed by small changes in pH levels, however developing young water plants and animals have little protection. Even small changes in the pH level could harm or even kill some plants and animals. pH levels that range between 6 and 8 on the pH scale (or near to neutral) are considered as indicators of a healthy creek, stream or river. A single unit change on the pH scale equals ten times the concentration of acid or base in the solution. pH levels below 5 are considered serious problems for aquatic life.

When water has a low pH, that is, it becomes acidic, it can cause other harmful elements to be released from the soil that surrounds the water. These elements, are called heavy metals, move into the water and are absorbed by the plants and animals that live in the water. The heavy metals can cause abnormal development and even death in young fish.

D. ***What human activities cause changes in the pH of water.***

Automobile exhaust and emissions from factories that burn coal for heat release elements into the air that are acidic. When these pollutants combine with moisture in the air and fall back to earth they can travel into lakes, streams and rivers. Sulfur Dioxide (SO_4) mostly from coal burning power plants are one source of pollution. Another source of pollution is from Nitrogen Oxides (NO) that come mostly from car and truck emissions

In the Adirondack mountains of New York more than 200 lakes have no fish and in some cases no living organisms at all. This is due to the acidic pH of the water resulting from pollution of the surrounding air. Birds and other animals that have depended on the plants and insects life of the lakes for food are also beginning to disappear.

Name ________________________ Date _________

TESTING THE WATERS: TOTAL PHOSPHATES (PO_4)

A. ***What does total phosphates test?***

Phosphorous is a non-metal and it is the 11th most abundant element in the crust of the earth. Phosphorous is found in many places in nature, including in natural waters. When found in nature phosphorous occurs as phosphate. This element is a necessary for plant and animal growth. Phosphorous is found in all animal bones in the form of calcium phosphate. This test is given to determine the level of phosphates in water.

B. ***What causes different phosphate levels in the water?***

One source for phosphates is from human waste and animal waste. Anytime waste material enters the water there is a concern about the level of phosphates. Phosphorous that collects in water can sometimes be stored in soils in the bottom of lakes rivers and streams. This phosphorous can be released into the water when that soil is disturbed. Many fertilizers and detergents contain phosphorous and when these enter the water through unsuitable sewage treatment or inappropriate farming techniques phosphate levels can rise.

C. ***How do changes in phosphates effect water quality.***

Phosphates in rivers and steams stimulates plants to grow well. As phosphate levels increase this causes plants to grow and grow. Eventually there can be too much plant growth for the water to support, and the plants begin to die. As the plants die bacteria in the water begin to decompose the dead plant parts. In the process the bacteria use up much of the available oxygen. Under these conditions it is difficult for aquatic organisms to survive. When the dead plant material builds up and the oxygen level is severely depleted the condition is referred to as **eutrophication**.

Shallow, slow moving water is very sensitive to eutrophication and if conditions are created where oxygen is completely used up a rotten egg smell can be noticed and the water looks like pea soup.

D. ***What human activities cause changes in the level of phosphates in water.***

There are many human activities that can contribute to increased amounts of phosphates in water. Soil erosion from can add phosphates to the water when the soil particles containing phosphorous are carried to the creek, river or stream. Erosion is of particular concern during times of flooding. In other cases the absence of plants, trees, grasses, and shrubs along the banks of the river allow soil to erode into the water.

Sewage that leaks from septic tanks or wastewater from treatment plants that is not properly handled can contribute to increased levels of phosphates. Treated wastewater that returns to the river should not contain more than 1 mg/liter of phosphorous.

Name ____________________________ Date ____________

So, What did you find out?

USING YOUR WATER TEST HANDOUTS AN HELP FROM THE TEST "EXPERTS" TO ANSWER THE FOLLOWING QUESTIONS. ORGANIZE YOUR ANSWERS ON A SEPARATE SHEET OF PAPER.

HOW DO WE KNOW? QUESTIONS

1. What does quantify mean?

2. If a creek's water quality was measured in the spring and the index indicated it was healthy water would it be necessary to ever test the water again? Explain.

NITRATES QUESTIONS

1. What is it about nitrogen levels that is a concern to those monitoring water quality of river creek or stream?

2. Describe how nitrates get into the water in a river or creek.

3. What is the chemical symbol for nitrogen? For nitrates? What is the difference between the two?

DISSOLVED OXYGEN QUESTIONS

1. Describe the two ways oxygen can get into a creek or river?

2. What effect would warm, slow moving water have on oxygen levels? Explain.

3. What happens to oxygen levels when the sun isn't shining? Would this make a difference on when you tested for dissolved oxygen? Explain.

4. What might cause sudden changes in the amount of oxygen in a river or creek?

5. If you can expect the level of oxygen in a creek or river to rise and fall how would you be able to determine if it is healthy water?

pH QUESTIONS

1. Draw your own pH scale and show where each of the common substances listed in the handout would be located. Find out the pH of at lease 3 other substances and place these on your scale also.

2. Would there be a concern about a creek or river that had a large amount of hydrogen ions? Explain.

FECAL COLIFORM QUESTION:

1. Why would it be important to note the weather conditions for several days before a fecal coliform count is taken?

PHOSPHATES QUESTION:

1. Why do you think it is easier for shallow slow moving water to undergo eutrophication?

2. What is the chemical symbol for phosphorous? For phosphate? What do you notice about the difference between the two.

3. Why is the following statement incorrect. A healthy creek or river is one which has no phosphates.

POLLUTION SOLUTIONS
Essential Question #3 Key Outcome B

Connections: Water Quality/Physical Science/Mathematics

OBJECTIVES:

Conduct dry lab water quality tests
Evaluate and analyze test results
Communicate test results
Ecosystem relationships

PREREQUISITE: Prior to the implementation of this simulation the instructor should demonstrate the procedures and techniques for conducting each of the four water quality tests.

MATERIALS:

Handouts for dissolved oxygen, nitrates, phosphates, and pH from Sample Lesson ***Testing the Waters.***
Handout ***Pollution Solutions*** (one for each student)
Test kits and instructions for pH, dissolved oxygen, nitrates, and phosphates (**Hach** kits are recommended)
Safety goggles
Latex Gloves
Containers for spent test materials
Butcher paper
Drawing paper
Glue, scissors, tape
Colored pencils and pens (optional)
(Optional) Reference materials for pH, dissolved oxygen, nitrates, and phosphates

SETTING UP:

In advance of the introduction of this project it is necessary to prepare several different simulated *Rolling River* water samples. It is suggested that each sample be pre-tested to ensure for the intended results before beginning the simulation. One quart of sample water should be adequate for every three groups using the sample.

Sample 1. High phosphates. To one quart of water add several drops of household plant fertilizer

Sample 2. High nitrates. To one quart of water add

Sample 3 Low pH. To one quart of water add of white vinegar

In order to manipulate dissolved oxygen levels of the samples allow sample jars to either remain tightly stoppered (low oxygen) or aerate samples by occasionally pouring the sample from one jar to another before testing.

Pour some sample material into sample jar containers for student groups to use for testing. Each group's sample jar should be marked (either by letter or number) and a master list of which sample material is in the different sample jars should be kept by the teacher.

Arrange all sample jars at a **Water Sample Station.** Next to this place safety goggles and latex gloves.

Arrange all test kits at **Water testing stations** and include a rag for wiping up spills and a marked containers to collect any spent testing material.

Design a rotation schedule for groups to conduct all four tests (depending on the number of available test kits).

CUE SET : Post and read the following quotation:

"If we knew a word for the dark spaces between pebbles on the river bottom, if we had a name for the nests of dried grass deposited by floods high in riverside trees, if there were a word apiece for the smell of pines in the sunshine and in the shadows, we would walk a different trail."

Kathleen Dean Moore

Discuss the quotation as it relates to learning about water quality and the way student perception has changed (the different trail) as a result of new concepts learned.

LESSON:

1. Divide students into cooperative groups of 4.

2. Explain the simulation involving water testing and reporting of results.

3. Give each student a ***Pollution Solutions*** handout. Read and discuss expectations.

4. Briefly review the importance of using the ***Testing the Waters*** handouts as resource material and point out any other resources gathered.

5. Discuss the rotation schedule for students to conduct individual tests, point out locations of safety equipment, first aid, and materials safety sheets for all test kits.

6. Conduct simulation.

7. After all groups have completed the project pieces and posted them on butcher paper allow for adequate time to prepare and practice presentations.

8. Student groups present their findings.

POLLUTION SOLUTIONS

You and your group members will be performing authentic water quality tests and evaluating the results as part of a simulation called ***Pollution Solutions.*** Authentic tests will be conducted on simulated river water samples taken from the fictitious "Rolling River." Your super detective team of experts will be responsible for using scientific method to accurately evaluate any problems with your water sample and propose changes that will improve the quality of water at your site. Your awesome group results will be presented at a watershed conference.

PROJECT REQUIREMENTS FOR THE GROUP

1. Conduct the following tests on your water sample. Dissolved oxygen, pH, nitrates, and phosphates.

2. Using information gathered from steps 1 & 2 above, create a table of results. Your data table will include:
   a. Test conducted and the results
   b. Examples of test results that would be expected for non-polluted water (As a comparison to your results)
   c. Comments and concerns - Tell whether or not there is a concern with the test results of your sample. If there is a concern make a list (brainstorm) possible environmental reasons causing your results.

3. After all of the test results have been analyzed your group must decide on realistic environmental conditions which could have caused the specific problems discovered with your sample. The environmental conditions **you** choose must relate to **your** test results.

4. Your group will be creating and writing a short story that describes a fictitious community along the Rolling River. In this story you will include a description of events (natural or man created) that have occurred explaining the environmental conditions at your test site. What is written here must relate to your test results.

   <u>Examples of events (past or present)</u>:

Drought, floods, earthquakes, dams, housing developments, feedlots, Industrial development, manufacturing plants, and agricultural development.

5. Each member of the group must write a biography that includes:

   a. Who you are (3-5 sentences)
   b. Your occupation (2-3 sentences)
   c. Why you are concerned about water quality, or how you became interested in it. (6-10 sentences)
   d. Why you are working on the Rolling River Project. (5-10 sentences)

6. Write a description of how your group will get community involvement in creating solutions for any problems discovered. Be specific, some suggestions include:

   -Alerting proper authorities
   -Forming special interest groups to create public awareness of problems and/or creating work groups for clean up
   -Making and posting signs to warn of dangers
   -Contacting polluters and sharing information gathered along with possible solutions for cleanup.

   There are many other possible actions that could result in solutions for cleanup, use your good thoughts and creativity to discover the possibilities.

7. Make a map showing a cross section of the river at your testing site. The cross section should be consistent with what you would expect to find given your test results. Pay careful attention to riparian zone conditions and aquatic life. In other words given your test results, and the causes of them, what would you expect the aquatic life and riparian zone to look like.

PROJECT PRESENTATION

1. Each group is responsible for creating a butcher paper display of their project pieces to be presented and justified during a student led conference. Each display must include project pieces # 2-7 above.

2. Each presentation will be about 10-15 minutes long. Decide who

will be responsible for explaining what water quality tests. Each member will tell about one of the tests. Suggestions for community involvement for improvement should be included in the presentation.

3. Use the following guidelines in preparing your speech.
   - -Tell who you are (brief biographical sketch), and what test you are speaking about
   - Tell what your results were for your sample
   - Explain any problems that may have occurred in the testing process
   - Explain what your test results mean. What is the on affect living things? Give examples if possible.
   - -Share any interesting information about your test. You may want to do a little extra research.
   - -Summarize your results

4. Practice as a group several times before presenting to the class and you will be awesome !

Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The single subject approach to curriculum design and implementation has been a prominent feature of American Education, yet researchers view this design as insufficient when considering the developmental needs of young adolescents.

In the literature examined researchers support the development and delivery of integrated curriculum, indicating that the opportunity to explore key concepts and significant issues using an integrated approach provides greater opportunity to formulate meaningful connections between complementary fields of knowledge.

Therefore an interdisciplinary curriculum correlating the environmental issue of water quality with the disciplines of physical science and mathematics was developed for use in the 6th grade at Wilson Middle School in Yakima, Washington.

Conclusions

Conclusions reached as a result of this project are:

1. Implementing integrated curriculum will create opportunities to explore significant issues and foster relevance in academic content

2. Educators who implement integrated curriculum can be reasonably assured that student achievement will not

decrease as a result of this approach

3. The natural connection that exists between mathematics and science facilitates integration of the two subjects and lessens the abstract qualities of both fields of study

4. Environmental concepts are well suited to an integrative approach

5. The study of water related concepts should be explored due to the significance of water as crucial to life

Recommendations

As a result of this project the following recommendations have been suggested:

1. Integrated curriculum design should be considered as an alternative to the separate subject approach in order to cultivate pertinence within the curriculum and to meet the developmental needs of middle school students

2. Additional experimental research should be reviewed in order to establish a stronger link between integrated curriculum and academic achievement and retention

3. Interdisciplinary curriculum should be designed and implemented carefully, drawing on experiences of

researchers in the field

4. Assessment procedures and instruments to evaluate the effectiveness of this interdisciplinary curriculum should be created and implemented

5. Assessment procedures and instruments to evaluate student attitude toward this interdisciplinary curriculum should be created and implemented

6. Other school districts considering the development of integrated curriculum may wish to adapt the model that was the subject of this project for their use

REFERENCES

Ackerman, D.B. (1989). Intellectual and practical criteria for successful curriculum integration. In H.H. Jacobs (Ed.), Interdisciplinary curriculum: Design and implementation (pp. 25-37). Alexandria, VA: Association for Supervision and Curriculum Development.

Adelman, N., Pringle, B. (1995). Education reform and the uses of time. Phi Delta Kappan, 77, 27-29.

Anson, R., Fox, J. (1995). Studies of educaiton reform: An overview. Phi Delta Kappan, 77, 16-18.

Beane, J.A. (1990). A middle school curriculum: From rhetoric to reality. Columbus, OH: National Middle School Association.

Beane, J.A. (1991). The middle school: The natural home of integrated curriculum. Educational Leadership, 49, 9-13.

Beane, J.A. (1992). Turning the floor over: Reflections on a middle school curriculum. Middle School Journal, 23, 34-40.

Beane, J.A. (1995a, January). Curriculum Definitions. Paper presented at the third annual National Conference on Curriculum Integration, Scottsdale, AZ.

Beane, J.A. (Ed.) . (1995b) . Toward a coherent curriculum. Alexandria, VA: Association for Supervision and Curriculum Development.

Berlin, D.F. (1989) . The integration of science and mathematics education: Exploring the literature. School Science And Mathematics, 89, 73-75.

Boyer, E.L. (1995) . The educated person. In J.A. Beane (Ed.). Toward a coherent curriculum (pp. 16-25). Alexandria, VA: Association for Supervision and Curriculum Development.

Bracey, G.W. (1994) . The fourth Bracey report on the condition of public education. Phi Delta Kappan 76, 115-127.

Brady, M. (1989) . What's worth teaching. Albany, NY: State University of New York Press.

Brady, M. (1993). Single discipline schooling. Phi Delta Kappan, 438-443.

Brunkhorst, B. (1991). Every science, every year. Educational Leadership, 49, 36-38.

Carnegie Council on Adolescent Development. (1989) . Turning points: Preparing American youth for the 21st century. New York: Carnegie Corporation.

Clark, D.C., and Clark, S.N. (1994) . Meeting the needs of young adolescents. Schools in the Middle, 4 , 4-7.

Davidson, D.M., Miller, K.W., Metheny, D.L. (1995) . What does integration of science and mathematics really mean? School Science and Mathematics, 95 (5), 226-230.

Eccles, J.S., Wigfield, A., Midgley, C., Reuman, D., Mac Iver, D., Feldlaufer, H. (1993) . Negative effects of traditional middle schools on students' motivation. The Elementary School Journal, 93, 553-563.

Edwards, J. (1991) . To teach responsibility bring back the dalton plan. Phi Delta Kappan, 73, 398-401.

Environmental Protection Agency. (1992) . Securing our legacy. (Office of Communications and Public Affairs publication No. 175 R-92-001) . Washington, D.C.: U.S. Government Printing Office.

Environmental Protection Agency. (1989) . Glossary of environmental terms and acronym list. (Office of Communications and Public Affairs publication No. 19K-1002) . Washington, D.C.: U.S. Government Printing Office.

Fiske, E.B. (1991) . Smart schools, smart kids. New York: Simon & Schuster.

Fort, D.C. (1993) . Science shy, science savvy, science smart. Phi Delta Kappan, 74, 674-681.

Friend, H. (1985) . The effect of science and mathematics integration on selected seventh grade students attitudes toward achievement in science. School Science & Mathematics 85, 453-461.

Glatthorn, A.A. (1994) . A quality Curriculum. Alexandria, VA: Association for Supervision and Curriculum Development.

Gore, A. (1992). Earth in the balance: Ecology and the human spirit. Boston: Houghton Mifflin.

Harrington, R.F. (1990). To heal the earth. Blaine, WA: Hancock House Publishers.

Hart, L.A. (1989) . The horse is dead. Phi Delta Kappan, 71, 237-242.

Howe, H. (1995) . Uncle Sam is in the classroom. Phi Delta Kappan, 76, 374-377.

Jacobs, H.H. (1989) . Interdisciplinary curriculum: Design and implementation. Alexandria, VA: Association for Supervision and Curriculum Development.

Jacobs, H.H. (1995, January) . Curriculum integration. Paper presented at the third annual National Conference on Curriculum Integration, Scottsdale, AZ.

Lawson, A.E., Bealer, J.M. (1984) . The acquisition of basic quantitative reasoning skills during adolescence: Learning or development? The National Asociation for Research in Science Teaching, 21, 417-423.

Mansfield, B. (1989) . Students' perceptions of an integrated unit. The Social Studies, 80, 135-140.

McBride, J.W., Silverman, F.L. (1991) . Integrating elementary/middle school science and mathematics. School Science and Mathematics, 91, 285-291.

National Commission on Excellence in Education. (1983). A nation at risk: The imperative for educational reform. Washington, D.C.: United States Government Printing Office.

National Council of Teachers of Mathematics. (1989) .

Curriculum and evaluation standards for school mathematics. Reston, VA: Author.

National Council of Teachers of Mathematics. (1991). Professional standards for teaching mathematics. Reston, VA: Author.

Orr, D. (1995). Earth in mind: On education, environment, and the human prospect. Washington D.C.: Island Press.

Palinscar, A.S., Anderson, C., & David, Y.M. (1993). Pursuing scientific literacy in the middle grades through collaborative problem solving. The Elementary School Journal, 93, 643-658.

Palmer, J.M. (1995). Interdisciplinary curriculum - again. In J.A. Beane (Ed.), Toward a coherent curriculum (pp. 55-61). Alexandria, VA: Association for Supervision and Curriculum Development.

Perkins, D.N. (1989). Selecting fertile themes for integrated learning. In H.H. Jacobs (Ed.), Interdisciplinary curriculum: Design and implementation (pp. 25-37). Alexandria, VA: Association for Supervision and Curriculum Development.

Perkinson, H.J. (1976). Two hundred years of American educational thought. New York: University Press of America.

Ralph, J., Crouse, J., Keller, D. (1994) . How effective are American schools. Phi Delta Kappan, 76, 144-150.

Rutherford, J.F., and Ahlgren, A. (1990) . Science for all Americans. New York: Oxford University Press.

Saveland, R.N. (1976). Handbook of environmental education. London: John Wiley & Sons, Ltd.

Shanker, A. (1990) . The end of the traditional model of schooling - a proposal for using incntives to restructure our public schools. Phi Delta Kappan, 71, 345-357.

Shanker, A. (1995) . A reflection on 12 studies of educational reform. Phi Delta Kappan, 77, 81-83.

Steen, L.A. (1991) . Reaching for scientific literacy. Change, 23, 11-19.

Turner, J.C., Meyer, D.K. (1995) . Motivating students to learn: Lessons from a fifth grade math class. Middle School Journal, 27, 18-25.

Vars, G.F. (1969) . Common learnings: Core and interdisciplinary team approaches. Scranton, PA: International

Textbook Company.

Vars, G.F. (1995, January) . Effects of interdisciplinary curriculum and instruction. Paper presented at the third annual National Conference on Curriculum Integration, Scottsdale, AZ.

Washington State Commission on Student Learning. (1995) . Essential academic learning requirements for science. Manuscript in preparation.

Yakima Public School District. (1995) . Science 6-8 course outcomes. (Available from Yakima Public School District, 104 N. 4th Avenue, Yakima, WA 98901)

Willis, S. (1992, November) . Interdisciplinary learning: Movement to link the disciplines gains momentum. Curriculum Update. Alexandria, VA: Association for Supervision and Curriculum Development.