This is to certify that the
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TEACHING WATER QUALITY IN A HIGH SCHOOL
BIOLOGY CLASS USING A CBL2 AND VERNIER PROBES.

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AARON MICHAEL WESCHE

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Merle K. Heidemann

Major Professor's Signature

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TEACHING WATER QUALITY IN A HIGH SCHOOL BIOLOGY CLASS USING A CBL2 AND VERNIER PROBES.

By

Aaron Michael Wesche

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ABSTRACT

TEACHING WATER QUALITY IN A HIGH SCHOOL BIOLOGY CLASS USING CBL2 AND VERNIER PROBES.

By

Aaron Michael Wesche

In today's technology-driven society it is important that teachers keep up by incorporating technology into their classrooms. Students are coming into the classrooms with a tremendous amount of knowledge in technology, and it is time we start letting them use that knowledge to help in their education. The purpose of this study was to measure whether or not there was improvement in learning when technology was incorporated into a unit on water quality. Students worked in the laboratory collecting water quality data using probes connected to a CBL2 interface and calculator. The student's improvement in basic knowledge was evaluated by their performances on pre-test and post-tests, quizzes, projects, and laboratory activities. The data show the new laboratory-based unit had a positive effect on the students shown by the improvement on tests, projects, and laboratory assignments. It can be concluded that student learning was improved by the use of technology in this unit.

I would like to dedicate this thesis to my loving family, Agnes and Alex. Thank you for all of your love and support. F/A.

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INTRODUCTION

The past twenty years have seen an unprecedented leap in technology. Buckley stated, "In fact, strides made in this short period of time far exceed the rate of technological advances of the entire 350 year span since Newton's time." It is not uncommon to hear a teacher say, "I just try to stay one step ahead of the students". This goal is becoming more and more difficult to accomplish. Students are coming into the schools with an amazing background in technology, often knowing more than the average High School teacher. A teacher wanting to have students involved in the class and take an active approach in learning needs to incorporate technology into the classroom. Many teachers are still using old simplistic methods of presenting information even though several studies have shown that students prefer strategies promoting active learning to traditional lectures (Bonwell and Eison, 1991). Bonwell and Eison state, "Many faculty assert that all learning is inherently active and that students are therefore actively involved while listening to formal presentations in the classroom." Students must do more than just listen: They must read, write, discuss, or be engaged in solving problems (Bonwell and Eison, 1991). In fact, school districts and governments are creating technology-planning teams, financial resources are being sought to purchase resources, and implementation models for technology are being critically examined (R.B. Buckley, 1995).

As Ambrose (2003) stated, "Few subjects in school are dependent on equipment as science." The average science classroom contains a wide range of so called tools of the trade. These tools range from glassware, thermometers, pipettes, and Bunsen burners to preserved specimens, and microscopes. These tools can attract the students' attention and enhance their learning of science. In order to keep up with recent technology innovations, it is important to add computers and computer accessories to the list of tools of the trade. Computers are no longer mere word processors or gateways to the Internet; computers are tools of exploration (Anderson, et.al, 1997).
Desktop/laptop computers or handheld devices can be transformed into data collecting, data storing, and data analyzing tools through the use of probes. The probes work by having a sensor that records the physical data, such as temperature of air or water. The sensor plugs into an interface, that converts the analog data into a digital format so the computer can process the data. The interface then connects to a computer or calculator so the data can

be analyzed. The advent of probes has allowed computers to thrive as active agents in student exploration of the natural and physical world (Marcum and Ford, 2003).

It was thought that computers would be able to simulate laboratory activities, which would allow teachers to forego actual laboratory activities (Marcum and Ford, 2003). Luckily, this idea has been primarily thrown aside in view of what educators know about student learning styles. Educators have learned there are at least three different learning styles. The first are visual learners. These learners need to see the teacher's body language and facial expression to fully understand the content of a lesson. These learners learn best from visual displays such as diagrams, illustrations, and overhead transparencies. Visual learners also prefer to take detailed notes to absorb the information. The second learning style is the auditory learners. These learners learn best through verbal lectures, talking things through, and listening to others and not taking notes. The third learning style is the tactile/kinesthetic learners. These learners prefer to learn through moving, doing, and touching. These are the learners who like hands on activities. Without laboratory activities, tactile/kinesthetic students will not have the best learning opportunity. Computer simulations will only help the students who learn by hearing and seeing the concepts, but do not help those students who need to be hands on and actually performing the activity. Computer simulations, while cheaper, easier, and cleaner, provide only a sterile lifeless representation of the wonder that constitutes science (Marcum and Ford, 2003).

Computer based probes succeed in science where computers simulations fail (Trumber and Gelbman, 2000). These probes allow students to experience science for themselves. They allow them to make choices about the direction of their research. Computer probes also decreases the amount of time spent on monotonous data collecting, storage, and data analyzing. Probes have many advantages for the students (Marcum and Ford, 2003). The probes can give the students immediate feedback through computer generated graphs, and statistics. With this students can make immediate connections between the data collected and the phenomena they observe in the laboratory (Marcum and Ford, 2003).

Many teachers question the role of computers and probes in the classroom. This arises from their lack of experience and lack of knowledge of the capabilities of the computer. In the High School science class, our primary goal is to provide students with a deeper understanding of scientific ideas, but a secondary goal for all teachers is to introduce students into the everyday world. For science teachers, it is our job to introduce students into what is referred to as "real science". To accomplish this goal, teachers should attempt to replicate the day-to-day activities of practicing scientists within the classroom laboratory (Jensen, 1998). Scientists rely heavily on computers in their work as they gather, store, organize, and analyze data, as well as communicate their finding with other scientists.

While technology may afford an opportunity for deeper cognitive processing and more authentic science learning, these benefits are not automatically realized merely because of the presence of technology (Salomon, 1992). Incorporating computers into the classroom is more than just letting students use the computer to type a research paper or surf the Internet. Teachers should incorporate computers into the classroom in ways that reflect true scientific research. Probes allow teachers to do just that as you research most aspects of biology. If students are to emulate the true scientific process of inquiry, computers need to be integrated into the science laboratory curriculum as research tools (Marcum and Ford, 2003).

According to Trumper and Gelbman 2000, by taking advantage of the computer's capabilities through the incorporation of technology into the science curriculum, students will be able to learn science as "novice researchers".

There are two main approaches to teaching science. The first is the constructivist approach. This approach is based on having students doing science in cooperative group settings performing thought-provoking experimentation (Baylor, et.al, 1996). Strommen and Lincoln (1992) state, "The foundational premise of constructivism is that learners actively construct their own knowledge by anchoring new information to preexisting knowledge." Unlike a constructivist classroom a typical science class consists of lecture, discussion, and laboratory. However, due to time constraints, an important component is often overlooked - authentic experimentation (Ambruso, 2003). Science is a social process and social interaction promotes learning via the discussion of different points of view (Driver et.al, 1994).

The second approach to teaching science is an objective approach. In the objective approach, the students look to the teacher and the textbook for answers. This is the basic lecture and worksheet-based class. Students in these classrooms learn to memorize facts and figures and then spit them out on a test. However, when the teacher asks an open ended question these students struggle thinking of an answer that is not found word for word in the textbook.

The constructivist classroom, although the preferred way to teach science, has its downfalls. These include, limited class time, a possible increase in preparation time, the potential difficulty of using active learning in large classes, and a lack of needed materials, equipment, or resources (Bonwell and Eison, 1991). Using probes in the classroom setting should provide a constructivist environment which, with the proper supervision, that is making sure all students are engaged, can be a phenomenal environment for student learning.

The research for this project was conducted at Michigan State University during the summer of 2003. The goal was to design a unit plan that will increase student knowledge in water quality using computer-based probes. A unit which integrates probes into a water quality unit in a high school biology class is the result of that research. Water quality was chosen for this project, because it is a topic not being taught in the school. The newly developed unit was meant to get students out of their seats and into the laboratory. It has very little paper and pencil worksheets; instead, the unit was based on cooperative groups working together to investigate the local watershed. All of the labs and activities were based on students taking responsibility for their learning and working together to gather and analyze data. The hardest part in developing this unit was to make sure the unit used the probes effectively. As Pederson and Yerrick (2000) said, "Computers, like all new pedagogical tools, must be properly and thoughtfully integrated into a curriculum." Computer probes must be integrated into the primary content and process of the course and not merely included as an add-on to the existing curriculum (Smith, et.al, 1999).

Basic Science Involved

Temperature

Temperature influences the amount of oxygen that can be dissolved in water, the rate of photosynthesis by algae and larger aquatic plants, the metabolic rates of aquatic organisms, and the sensitivity of organisms to toxic wastes, parasites, and disease. Humans cause changes in temperature through, e.g., thermal pollution, cutting down trees, and adding in soil erosion. Thermal pollution is an increase in water temperature caused by adding warm water to a body of water, the warm water may come from, e.g., nuclear power plants, and storm water runoff. Soil erosion will increase the amount of suspended solids in the water; these absorb sunlight also warming the water. The rate of photosynthesis increases as the temperature increases. This will lead to more plant growth and eventually more plant death, which stimulates decomposers and bacteria that will consume the oxygen as they decompose the dead plants. Increased temperature also increases the metabolic rate of organisms which, in turn, causes them to use more oxygen. Fish can become more vulnerable to disease with increased water temperatures.

<u>pH</u>

Water is composed of two ions, H^+ (hydrogen) and OH^- (hydroxide). pH is the concentration of these two ions. Neutral water with a pH of 7 has an equal concentration of hydrogen and hydroxide ions. A solution with a greater concentration of hydrogen ions is considered acidic (pH of 1.0 - 6.9), while a solution with a greater concentration of hydroxide ions is considered a base (7.1 - 14.0). Factors that affect the pH levels in lakes and streams are, acid rain, algal blooms, hard water minerals, industrial processes, and oxidation of sulfides in sediments.

<u>Dissolved Oxygen</u>

Dissolved oxygen is the amount of oxygen per units of water in an aquatic environment. Organisms use oxygen for cellular respiration. Factors that affect the dissolved oxygen levels are temperature, aquatic plant populations, decaying organic material in water, stream flow, and human activities. Dissolved oxygen fluctuates throughout the day: levels will rise in the morning, reach a peak in the afternoon, and decrease in the evening.

Chloride

Chloride is a negative ion coming from the dissolution of salts such as sodium chloride or calcium chloride in water. There are many sources of chloride ions; river streambeds with salt-containing minerals, runoff from salted roads, irrigation water returned to streams, mixing seawater with freshwater, and water softener regeneration. Freshwater streams and lakes have a significant chloride level that can range from 1 to 250 mg/L.

Nitrates

Nitrates are used by plants and animals to make amino acids and proteins. Some sources of nitrates are agricultural runoff, urban runoff, animal feedlots, industrial wastewater, automobile emissions, and decomposition of plants and animals. Levels above 10mg/L in drinking water can lead to methemoglobinemia or blue baby syndrome. Excessive nitrates can cause lakes to become eutrophic as well. Freshwater normally has levels in the range of 0.1 to 4 mg/L. Unpolluted waters should have levels below 1.0 mg/L.

Macro-Invertebrates

Macro-invertebrates can be used to determine water quality. By collecting the invertebrates and identifying them, it can be determined if the water is of good quality or not. Invertebrates are affected by four main factors: water temperature, discharge patterns, substrates, and energy relationships. Invertebrates have adaptions to live in the rivers. For example, during floods, invertebrates burrow into the substrate to avoid being swept away. River invertebrates have also developed a flat body, which allows them to remain in the protective boundary layer of rocks. This flattening also permits them to avoid the current by crawling under rocks. Other examples of evolutionary developments of aquatic invertebrates are: the ability to produce silk to anchor them to rocks, and the ability to construct homes of stones, vegetation, and sand particles for protection.

Stream Flow and Velocity

Stream flow is the volume of water that moves through a specific point in a stream during a given period of time. Stream flow is determined by measuring a cross sectional area of the stream using a flow rate sensor. The volume can be calculated by multiplying the cross-sectional area by the flow velocity. Factors that affect the flow velocity are: depth of stream channel, width of stream channel, roughness of stream bottom, and slope or incline of surrounding terrain. The factors that affect the stream volume are: weather or climate, seasonal changes, merging tributaries, and human impact.

Total Solids

Total solids are a measure of all the suspended, colloidal, and dissolved solids in a sample of water. Siltation is the most common pollutant of streams and rivers. Soil erosion and organic matter can affect the levels of total solids. Levels too high or too low can impact the health of the stream and the organisms that live there. High levels will decrease the rate of photosynthesis. High levels will also increase the temperature, which affects the river in many ways. Total solids should fall with the range of 20 mg/L to 500 mg/L.

Total Dissolved Solids

Total dissolved solids are the total of suspended and dissolved solids in a stream. This includes silt, stirred up bottom sediment, decaying plant matter, and sewage treatment effluent. Evaporating a pre-filtered sample to dryness, and then finding the mass of the dry residue per liter of sample is a way to measure total dissolved solids. Hard water ions, fertilizers, urban runoff, and acidic rainfall can all affect the levels of total dissolved solids. Lakes and streams typically tend to be between 50 - 250 mg/L.

Fecal Coliform

Fecal coliform bacteria are found in the feces of humans and other warm-blooded animals. They can enter the river through direct discharge from the animal, or from runoff. Fecal coliform themselves are not pathogenic. However, fecal coliform bacteria are found along with pathogenic organisms and is an indicator of contaminated water. Pathogens are relatively scarce in water making them difficult and time-consuming to monitor directly.

The study group used in this research consisted of 32 students in a college preparatory Biology One class, all of whom are Caucasian and live in a rural area. The students were in their second year of high school, and in their second or third science class of their high school career. All had taken a freshman science class and some had taken an introduction to biology class before entering Biology One. This study will document students using probes in a constructivist atmosphere to study a local resource.

Chapter 1: Implementation of Unit

This study will document students using probes in a constructivist atmosphere studying a local resource. This unit is the result of research conducted during the summer of 2003 at Michigan State University. The goal of the research was to design and assess a unit plan to use in the biology classroom, integrating new hands-on activities. Students who participated in this study were sophomores and juniors in their second high school science class. Most freshmen take a survey course that covers Earth science and physical science. Other, more advanced freshmen take a laboratory-based honors science class. This study was conducted in a college preparatory biology class. The school does offer a lower level biology class for those students who do not intend on furthering their education in college. The unit is broken into seven weeks of activities and assignments (see table 1).

The unit started out with a pre-test on general issues about water quality. Students were instructed to answer every question as completely as possible. The pre-test consisted of multiple choice, true and false, and essay questions, and was used to determine the prior knowledge students had of water quality.

Table 1: Daily Lesson Plans for Water Quality Unit.

Week	Monday	Tuesday	Wednesday	Thursday	Friday
1ST WEEKS BIG IDEAS .	Pre-test on water quality	Notes: Introduction to CBL2 and TI83+ calculator. Temperature activity	Overview of water quality tests. Assign two projects.	* Leaf Packs Make them and put them in river Groups of 3, each group makes 2 packs	Class notes on temperature and pH. What do they mean?
2ND WEEKS BIG IDEAS	Demo: Temp and pH probes Use calibration	* Class activity. Temp and pH probes Take readings of various solutions	Quiz: using pH and temperature probes, and class notes.	Class notes Chloride and dissolved oxygen. What do they mean?	Class demo, chloride dissolved oxygen
3RD WEEKS BIG IDEAS	* Class activity chloride and dissolved oxygen of various solutions	Quiz: Chloride and dissolved oxygen	Class notes on nitrate and total dissolved solids	Class Demo: nitrate and total dissolved solids	* Class activity: nitrate and total dissolved solids
4TH WEEKS BIG IDEAS	Quiz nitrate and total dissolved solids	Class notes total solids and fecal coliform	* Class activity: Total solids	Class notes on Stream flow and stream volume	Quiz total solids flow, volume, fecal coliform.
5TH WEEKS BIG IDEAS	Finish total solids activity	Practice day for all water tests	Practice Day for all water tests	Practice day for all water tests	Practice day for all water tests
6TH WEEKS BIG IDEAS	*Trip to stream perform tests, take out leaf pack	Sort Leaf Packs and Identify Microorganisms	Trip to waste water treatment plant	Project presentations	Project presentations
7TH WEEKS BIG IDEAS	Project presentations	Project presentations	Review day	Post test	

* Newly implemented activities

**Any extra time will be spent working on projects in class.

***Homework will be included periodically

The pre-test also allowed the instructor to determine what areas would require more time to ensure student comprehension. The majority of students did not have any background information on water quality as shown by the results of the pre-test (figure 1 p32). They had no idea how water got from its source to their house. Besides having the students working in groups at hands-on activities and probes, the unit was meant to have the students think on their own instead of looking in the book for answers. The students were presented with an opportunity to take a cognitive approach to their learning. They were asked to take the information presented to them and apply it to real life applications. The information was presented to the class using attractive PowerPoint lecture notes, which were developed as part of this unit plan. Students were also given a copy of the notes before hand, which allowed them to spend more time participating in the discussion and learning about the water quality tests being presented. Participation by the students in the discussion lets the instructor know if the students were grasping the concepts presented to them. Besides the limited time actually taking notes and listening to lecture, the students spent time in the lab performing hands-on activities and using the information presented to them in the lectures. The hands-on activities and technology allowed the students to take an active role in their learning, requiring them to take responsibility for their learning. The students first had to learn how to operate the technology used in the labs before they could complete the water quality testing. This took significant instruction. All of the labs were based on using a Vernier CBL2 connected to a TI83+ calculator. Students then attached a Vernier probe to the CBL2, which allowed them to conduct various water quality tests. The CBL2 is a hand held computer that gathers data, and the TI83+ calculator has the ability to store and analyze data. Cavallo and Shafer (1996) said, "to increase meaningful learning, educators must make the content personally relevant", which was done by having the students study the watershed in their town. Based on classroom discussion, it was known they had a preconceived idea that the local watershed was heavily polluted until we started testing it. The students were also given an attitude survey (Appendix F) that included many different areas of biology and water quality.

They had the opportunity to rate different phrases from 1-5 depending on how they felt. (Appendix G).

Week one continued with a lesson introducing the CBL2 and TI83+ calculator. A PowerPoint slide was used to show the students how to use the system and where different applications were stored on the calculator. The instructor also showed the students how to use the calculator by using a view screen that projects the calculator screen on the overhead screen. Students followed along with their calculators. Students were sent off to different parts of the school to take temperature readings using the CBL2, TI83+, and Vernier Temperature probe. Students then came back to the room and recorded the temperature in each area of the school on the chalkboard (including the Superintendents body temperature). This was a very engaging activity for the students and started a heated conversation as to why the Superintendent and Principal's offices were air conditioned while students were sitting in a classroom that was over twenty degrees warmer. This was also a great way to introduce the students to how complicated the set up can be if they don't follow directions precisely. The students then were shown how to use the statistical package on the calculator. The students were also instructed on how to perform a T-test using the calculator. Students used the t-test to compare the means of each set of water quality data collected. This will be especially important when the students analyze the data from samples of water below the waste water treatment plant and water above the waste water treatment plant. The third day the students were presented with information on what water quality tests we were going to learn and a general overview of water quality. After the second day two assignments were given. The first assignment to be completed by the end of the unit was a group project. They were given three options. The first was to design a collage presenting a theme related to water quality. The collage should portray a message about water quality. The second option was to design an advertisement poster for the local watershed to introduce people to the parks and areas along our watershed. The students were trying to make something our local watershed committee could use. The third option was to design plans for a community park to be renovated in town. The town has a nice area for a park next to the river. The plans could be taken to the planning commission to see if it is something that could be done. The majority of students picked this third option.

The second assignment for this unit was an individual project. The students were to pick a river in the United States and design a river research poster. They needed to research the water quality of that river and present this information on a poster to the class in a five-minute presentation. Students were to find water quality data based on tests we were studying in class. Both of these projects were due at the end of the unit.

The first week continued with students making leaf packs. Leaf packs are bricks that are placed in the river after they are wrapped in leaves and tied with fishing line. The leaves attract micro-invertebrates which can be collected later. The leaf packs were put in the river at two different points: One in town, and one south of town below the water treatment plant.

The first week finished with a presentation of notes related to the question, "Why is temperature and pH important in terms of water quality?" Students were given a copy of the PowerPoint notes before the lecture. A great deal of time was spent discussing pH.

Week two began by spending time in the lab calibrating and practicing with the temperature and pH probes. Students brought in samples of water from home to test, and the instructor had some acids and bases made up for the students to test. After students had time to work on the probes and listen to the lectures on a particular probe, they were given a quiz. The quizzes were peer-graded in class, followed by a group discussion of the quiz. Week two finished with class notes on chloride, fertilizers, and rain runoff. To understand dissolved oxygen, we needed to discuss the oxygen/carbon-dioxide cycle so students understood how oxygen is used/consumed and how carbon dioxide is introduced into the environment. The main goal of the discussion of dissolved oxygen was to teach the students how dissolved oxygen changes according to temperature.

Week three began by practicing with the chloride ion probe and dissolved oxygen probe. Students were also to use the day to review temperature and pH and prepare for the quiz on chloride and dissolved oxygen. Week three continued with a presentation of notes on nitrates and total dissolved solids. Then students were shown a demonstration on how to use the nitrate and total dissolved solids probes. Because both of these probes can be confusing to use, extra time was taken. Week three concluded with students practicing using these probes.

Week four began with students taking a quiz over the nitrate and total dissolved solid information. In week four, students were introduced to the total solids, fecal coliform, stream flow and stream volume tests. After the notes on these tests, students were given an opportunity to practice performing these tests except for fecal colifom and stream flow. Week four concluded with a quiz on total solids, flow, volume, and fecal coliform. After the quiz students finished the total solids lab (appendix B).

Week five was used as a review week for students to practice using the probes in class. If students were done with the probes they could work on their River Research or River of Dreams projects instead.

Week six started with a trip to the river where the students needed to perform every water quality test we had studied, and record their results. This was a culminating activity for the students. The students had spent five weeks in the lab practicing the tests for this trip to the river. The instructor went to the river the day before and ran all of the tests to make sure they worked properly and to obtain a data set to compare with the students. Students were graded on their proficiency with the probes, and the data collected from the stream. Proficiency with the probes was determined by observation and by comparing the students' data with the data the instructor collected the day before. While at the river, students collected the leaf packs and put them in plastic bags to bring back to the classroom. The next day was spent gathering and identifying the microorganisms from the leaf packs. The last major activity for the unit was a trip to the water treatment plant. Students were introduced to the water testing aspect of the plant. Students were also allowed to perform some water tests at the plant. This was added to comply with the schools push for introduction to possible careers.

The rest of week six and the beginning of week seven was spent presenting river research projects. Each group was to spend five minutes in front of the class presenting their river of dreams project, whether it was a collage, advertisement, or design for a park. Students also were required to spend five minutes in front of the class presenting their river research poster. After the presentations, students spent time reviewing for the post-test and the last day of the unit was the post-test. The post-test (appendix A) was an expanded form of the pre-test. The post-test included each of the questions on the pre-test mixed in with other questions.

Labs used in Unit

There were some general problems with the lab activities. First, it was a challenge to have the students read the instructions to the labs step by step. They tended to skip some steps which caused great confusion. Secondly, students often did not connect the CBL2 and calculator correctly. They would not push the cable into the calculator all the way. Finally, the last problem was the amount of time it took to prepare the probes. Some of the probes needed to warm up for 30 minutes before use.

Temperature and pH Lab (appendix B)

The objective of this lab was to introduce students to the temperature and pH probes. They were to take readings of various samples of water, acids, and bases. Students were to perform a t-test to determine if the samples of water were significantly different in terms of temperature, and then again for pH.

Chloride and Dissolved Oxygen Lab (appendix B)

The goal for this lab was to get the students comfortable setting up, calibrating and using the chloride and dissolved oxygen probes. After collecting the data students needed to perform t-tests again to determine if there was a difference in chloride, and dissolved oxygen between the two samples of water.

Nitrate and Total Dissolved Solid Lab (appendix B)

The students used the conductivity probe to determine the total dissolved solids, and a nitrate probe to determine the nitrate levels in two samples of water. The object of this lab was to give the students some practice in calibrating and setting up the probes. Students needed to run a t-test on the data from the lab.

Total Solids Lab (appendix B)

Students found this lab to be very interesting. They had not previously realized how much sediment was in the river water. Students took clean massed beakers and filled them with river water. Students then put them in an oven to evaporate the water. When all of the water was gone the students reweighed the beaker to discover how much solid was in the water. This lab was easy for the students; it requires two days to finish.

Leaf Packs (appendix B)

The objective of this activity was to determine the water quality of the river by recording the macro-invertebrates found in the river. The hardest part was the identification of the microorganisms. Students did a nice job on this lab, and found it very interesting.

Stream Trip Lab

This lab was a summation of every lab we had done during this unit. The students were to go to the stream and perform every lab we had practiced in the classroom. Students posted their data on the chalkboard when we returned to the classroom and we found the class averages. After performing the labs, we spent time cleaning debris from the river. Those students who did not like taking readings of the water quality really got into cleaning the river. The major element of pollution was the softballs in the river.

Chapter 2 Data Collection Methods.

Pre and Post Tests

Before the students started this unit, they took a pre-test (appendix A) so the instructor could determine how much prior knowledge they had in the area of water quality. It consisted of eleven multiple-choice questions, eight true and false questions, and four essay questions. The essays ranged from drawing graphs, listing factors, to answering a situation problem. For example, the first essay asked the students to draw a graph showing the relationship of amounts of dissolved oxygen vs. the time of day. The essay was graded using rubric C (see table 2). Another essay asked the students to explain why someone who is fishing at a deeper depth is catching more fish than someone who is fishing at a shallower depth. This essay was graded using rubric A (see table 2). After completion of the unit, the students took a post-test (appendix A). The post-test consisted of twenty-nine multiple-choice questions, twenty-six true and false, and ten essay questions. The essays on the post-test not only contained the questions from the pre-test, but had an additional six questions covering various topics. For example, one question asked the students to list the factors that affect the distribution and abundance of aquatic insects in a stream. Other questions asked the students to describe the factors that control a river current's speed, and describe how invertebrates can be used to evaluate water quality. All of the questions in the pre test were also in the post-test word for word for valid statistical analysis.

The essay questions on the pre and post-test were graded using the following rubric (see table 2). The rubrics required students to complete answers with complete sentences and correct grammar. Students were given partial credit if they came up with the correct response but did not use complete sentences. Students were awarded one point for attempting to answer the question. This was done to make sure that students answered every question.

Table 2: Rubrics used to grade pre- and post-tests.

Rubric A.

1	2	3	4	5
Attempted question. Incomplete sentences. Incorrect response	Attempted Question Partially correct response. Incomplete sentences	Attempted Question. Partially correct response. Complete sentences	Attempted Question. Correct Response. Incomplete sentences	Attempted Question. Correct Response. Complete sentences

Rubric B.

1	2	3	4	5
Attempted question. Incorrect	Attempted Question. Listed 1	Attempted Question. Listed 1	Attempted question. Listed two	Attempted question. Listed two

response	correct factor. Incomplete sentences	correct factor. Complete sentence	correct factors. Incomplete questions	correct factors in complete sentences.

Rubric C.

1	2	3	4	5
Attempted graph. Line is incorrect. But graph is in correct format	Attempted graph. Line is correct. Axis are not labeled. No title. Intervals are incorrect	Attempted graph. Line is correct. Axis are not labeled title is present. Intervals are correct.	Attempted graph. Line is correct. Title is not present. Axis are labeled. Intervals are correct	Attempted graph. Line is correct. Title is present. Axis are labeled. Intervals are correct

Data Gathering from Weekly Quizzes

Students were given quizzes (appendix E) every week on the water quality testing procedure they studied that week. These quizzes were based on the notes presented to them in class. It was expected based on constructivist ideas that the notes and practice with tests would lead to understanding. The quizzes consisted of short answer essay and longer essay questions. The quizzes were peer graded in class with a discussion following the grading.

Attitude Survey

Students were given an attitude survey (appendix F) to determine their overall feeling for biology especially topics related to water quality. Students ranked their responses 1-5 on each question. The questions ranged from overall attitude of biology to specific topics of biology such as cell biology, ecology, and water quality.

Chapter 3: Results and Evaluation

1) Pre/Post-Test Analysis

The main goal of the pre and post-test comparison was to determine whether the students attained an understanding of water quality (water testing).

The pre-test data (figure 1) showed that the students had very little prior knowledge of water quality. The lack of knowledge of water quality is not surprising since this subject is not studied in middle school. For example, very few students knew the levels of different chemicals in water (see figure 1, question 4).

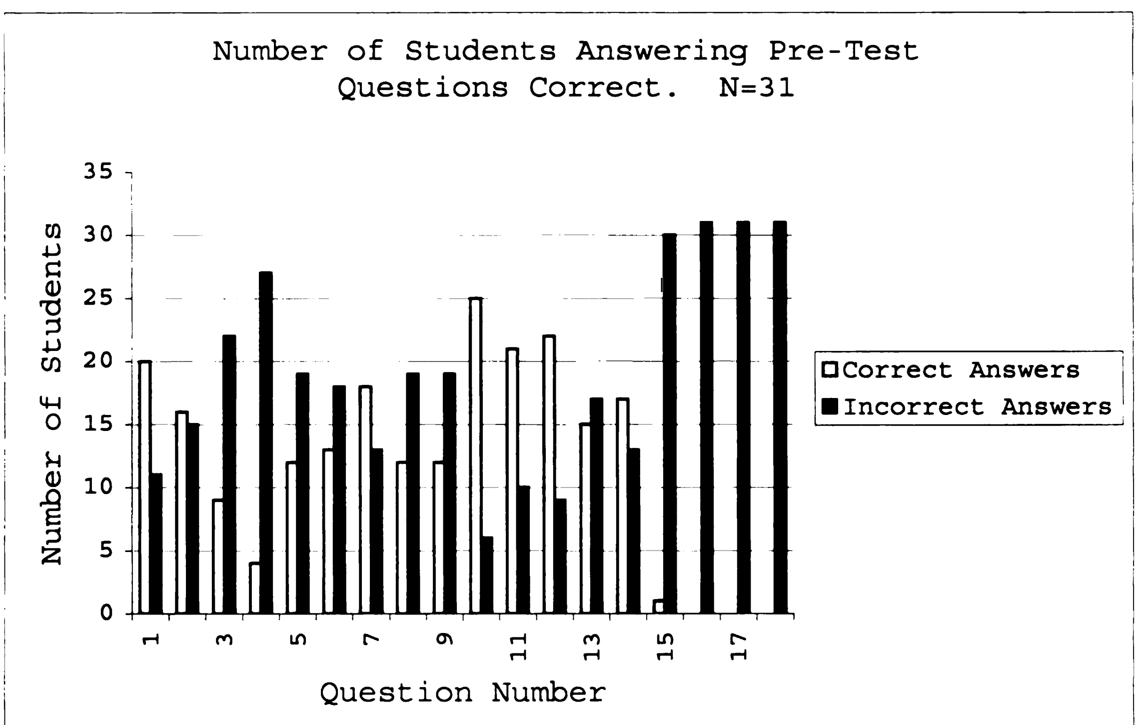


Figure 1: Graph showing number of students answering pre-test correct and incorrect.

Students also had very little knowledge about fecal coliform, and pathogens (see figure 1, question 4). Not one student could list four significant factors that affect the distribution and relative abundance of aquatic insects in a stream or list two examples of macro-invertebrates evolving to live in the current of a river (see figure 1, questions 21, and 22).

All but two of the questions on the pre-test had an average correct response of less than seventy percent (see figure 1). The last four questions were open-ended essay questions; only one student answered one of those questions correctly. Questions ten and twelve had an average of over seventy percent. Question ten was a question asking what two ions make up water. Question twelve asked about rivers being void of aquatic life if dissolved oxygen levels are too low. Students have been taught about the chemical make-up of water in previous classes so that is not surprising, but students have not been taught about dissolved oxygen until now.

The post-test data shows tremendous improvement in student knowledge of water quality. The greatest improvement was in the essay questions (see figure 2). The students had an 81% improvement on the first essay question on the post-test. On the pre-test only 3% of the students answered the question adequately, while 84% of the students answered it adequately on the post-test. The last three essay questions showed improvement also. On the pre-test, 0% of the students answered the questions adequately. On the post-test, 25% of the students answered the second essay adequately while 38% answered the third essay adequately, and 69% answered the fourth essay adequately. This was an overall improvement of 53% on the essay questions. There were ten questions on the post-test (appendix A) with an average of over seventy percent. There is an improvement in student knowledge in every question except one, question

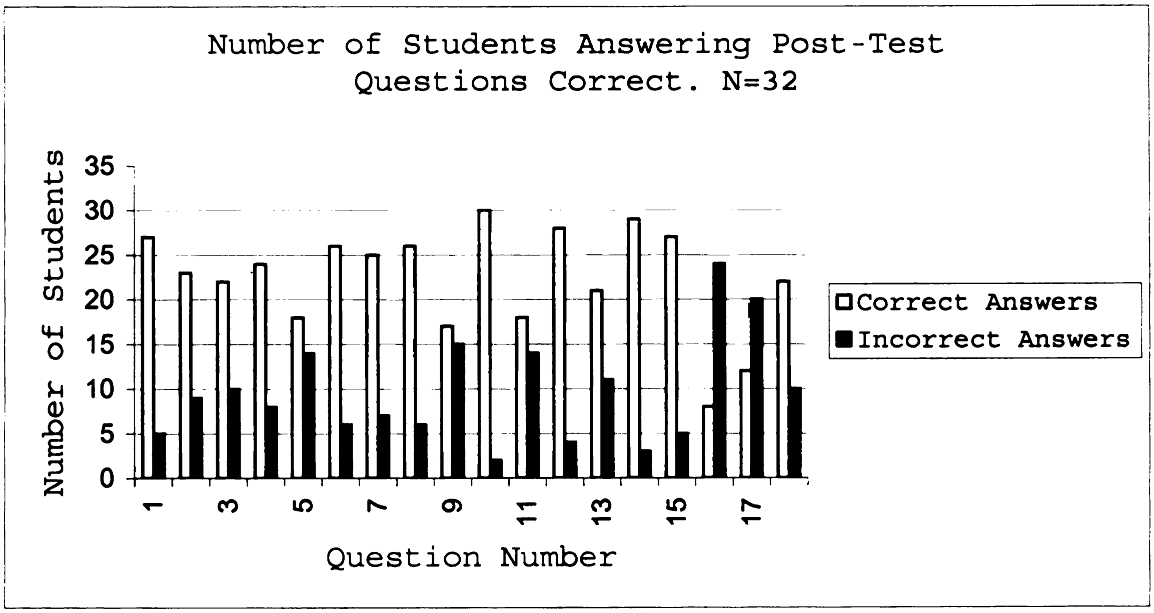


Figure 2: Graph of Number of Students Answering Post-Test Questions Correct.

eleven (see figure 2). This question asked if fecal coliform were pathogenic. The greatest improvement was on the first essay question, where there was an eighty-one percent increase in the number of students answering the question correctly (see figure 2).

There was an overall average increase of thirty-one percent on the post-test. The data from the pre-test and the post-test was calculated and a t-test was performed to compare the averages. The average on the pre-test was a 37% with a standard deviation of 8.56, while the average on the post-test was a 77% with a standard deviation of 19.05. This looks to be a pretty significant difference (see figure 3), which a t-test will only show.

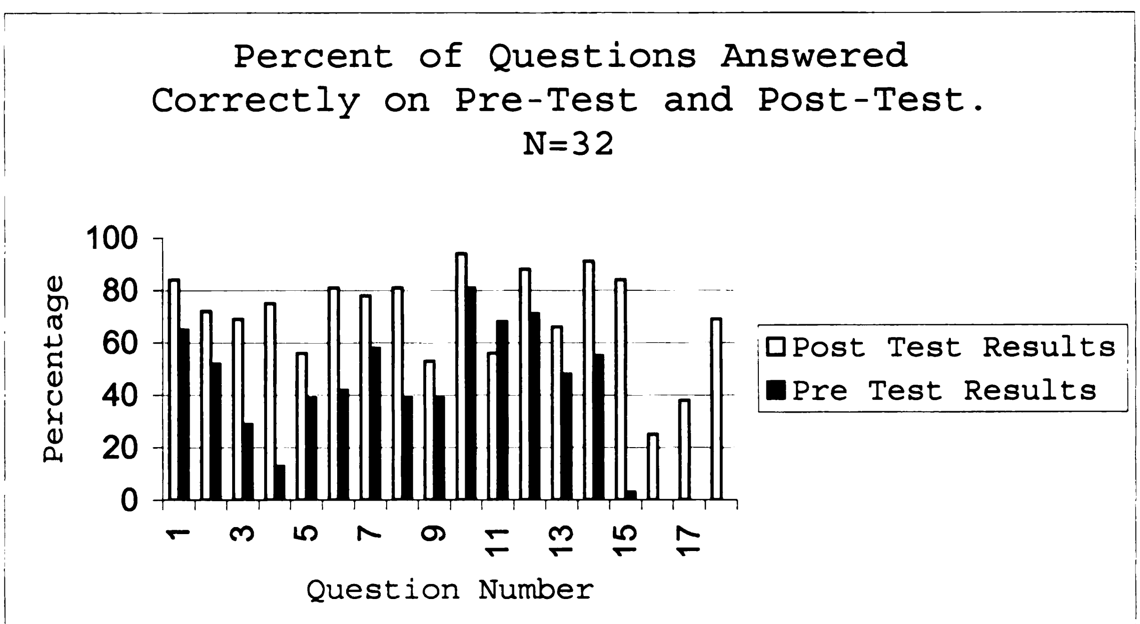


Figure 3: Percent of Questions Answered Correctly on Pre-Test and Post-Test.

The p value found in the t-test was less than 0.000. The p value must be less than .05 for the data to be significantly different.

2) Labs and Quizzes

The students were graded on the labs on a completion/no completion scale. (If they completed the lab, they received the credit for it). They were graded on their proficiency with the probes when the class made the trip down to the river. Twenty-six of the thirty-two students (81%) performed well enough to earn a passing grade working with the probes.

The quizzes students took after each water quality test covered were graded in class by their peers. Students did well on the quizzes. The students did the worst on the quiz covering dissolved oxygen and chloride (see table 3).

Table 3: Average Quiz Scores.

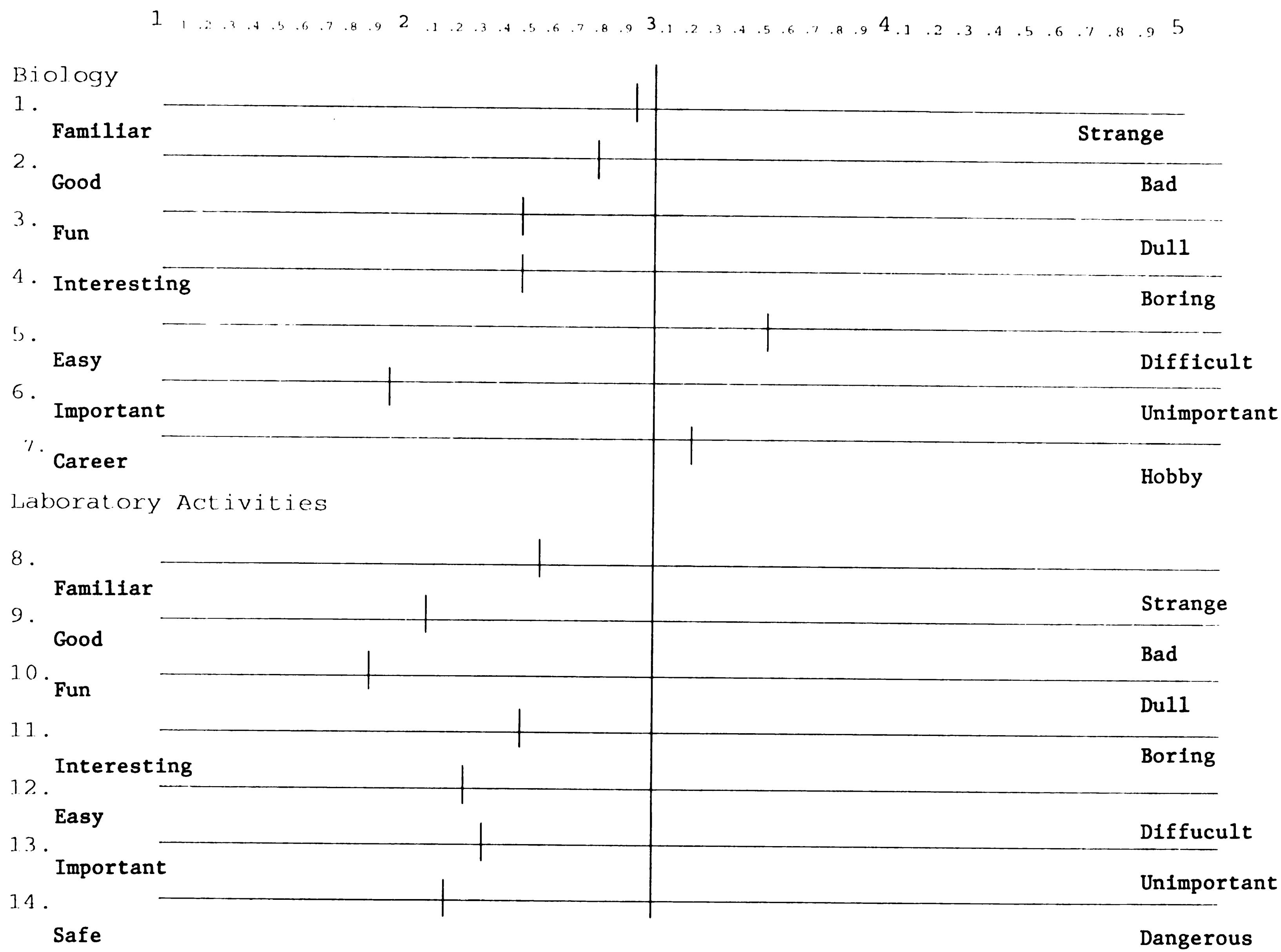
Quiz	Class Average
Ph and Temperature	82%
Nitrate and Dissolved Solid	78%
Macro-Invertebrate	89%
Fecal Coliform and Total Solid	77%
Chloride and Dissolved Oxygen	64%

The best quiz average was the quiz on macro-invertebrates. The students knew what to expect on that quiz and was made up of matching. The other quizzes were all short answer essay.

3) Attitude Survey Results

The attitude survey (Appendix F) was a tool designed to determine the overall attitude students had towards ten different aspects of biology; biology, laboratory activities, working in teams to solve problems, scientific method, water testing, recycling, local rivers, cell biology, ecology, and DNA/genetics. At the beginning of this unit, students were given sixty situations to rank how they felt between 1(very positive) and 5(very negative). The answers for each situation were then averaged (see table 4). An answer between 1 and 2.9 is considered a positive response, while 3.0 to 5.0 is considered a negative response. For example, question 41 on the attitude survey asked the students to rank whether they felt the local rivers were clean(1) or polluted(5). The average answer for that question was a 3 (see table 4). Question 16 asked if working in teams to solve problems was good(1) or bad(5). The average answer was 2.1(see table 4).

Table 4: Results of Attitude Survey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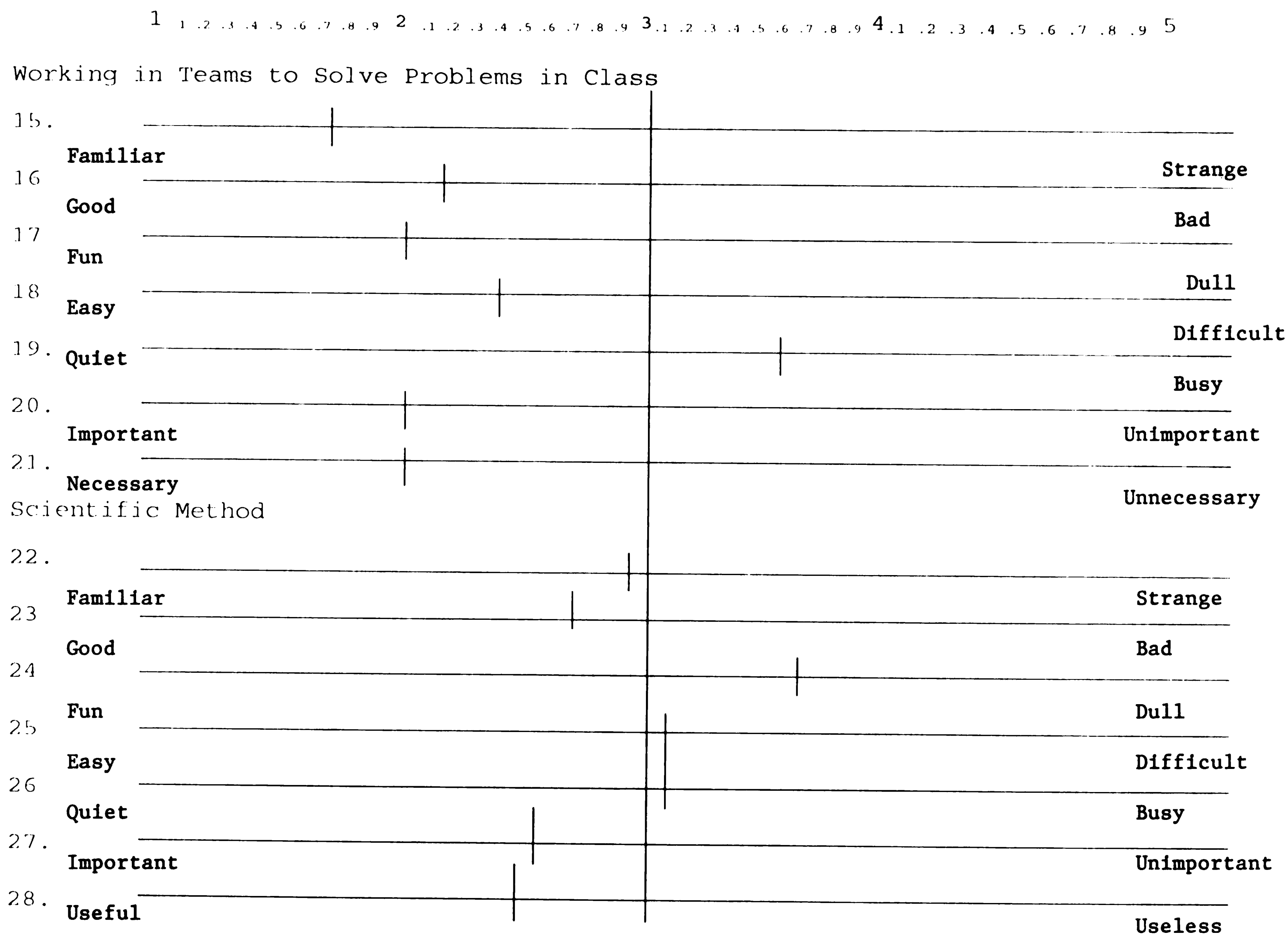
Biology
1. Familiar
Strange
2. Good
Bad
3. Fun
Dull
4. Interesting
Boring
5. Easy
Difficult
6. Important
Unimportant
7. Career
Hobby
Laboratory Activities
8. Familiar
Strange
9. Good
Bad
10. Fun
Dull
11. Interesting
Boring
12. Easy
Diffucult
13. Important
Unimportant
14. Safe
Dangerous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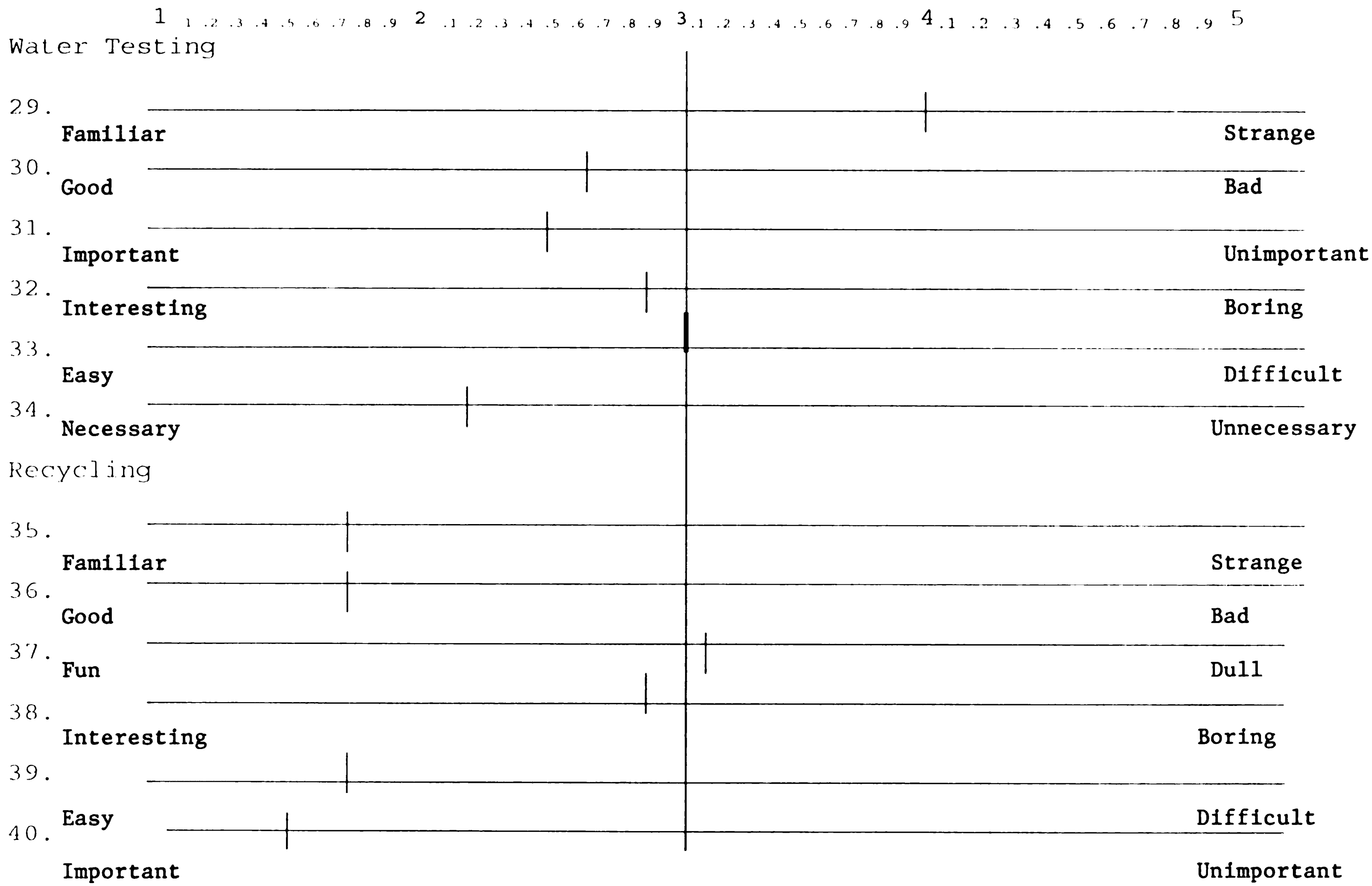
Working in Teams to Solve Problems in Class
15. Familiar
Strange
16 Good
Bad
17 Fun
Dull
18 Easy
Difficult
19. Quiet
Busy
20. Important
Unimportant
21. Necessary
Unnecessary
Scientific Method
22. Familiar
Strange
23 Good
Bad
24 Fun
Dull
25 Easy
Difficult
26 Quiet
Busy
27. Important
Unimportant
28. Useful
Useless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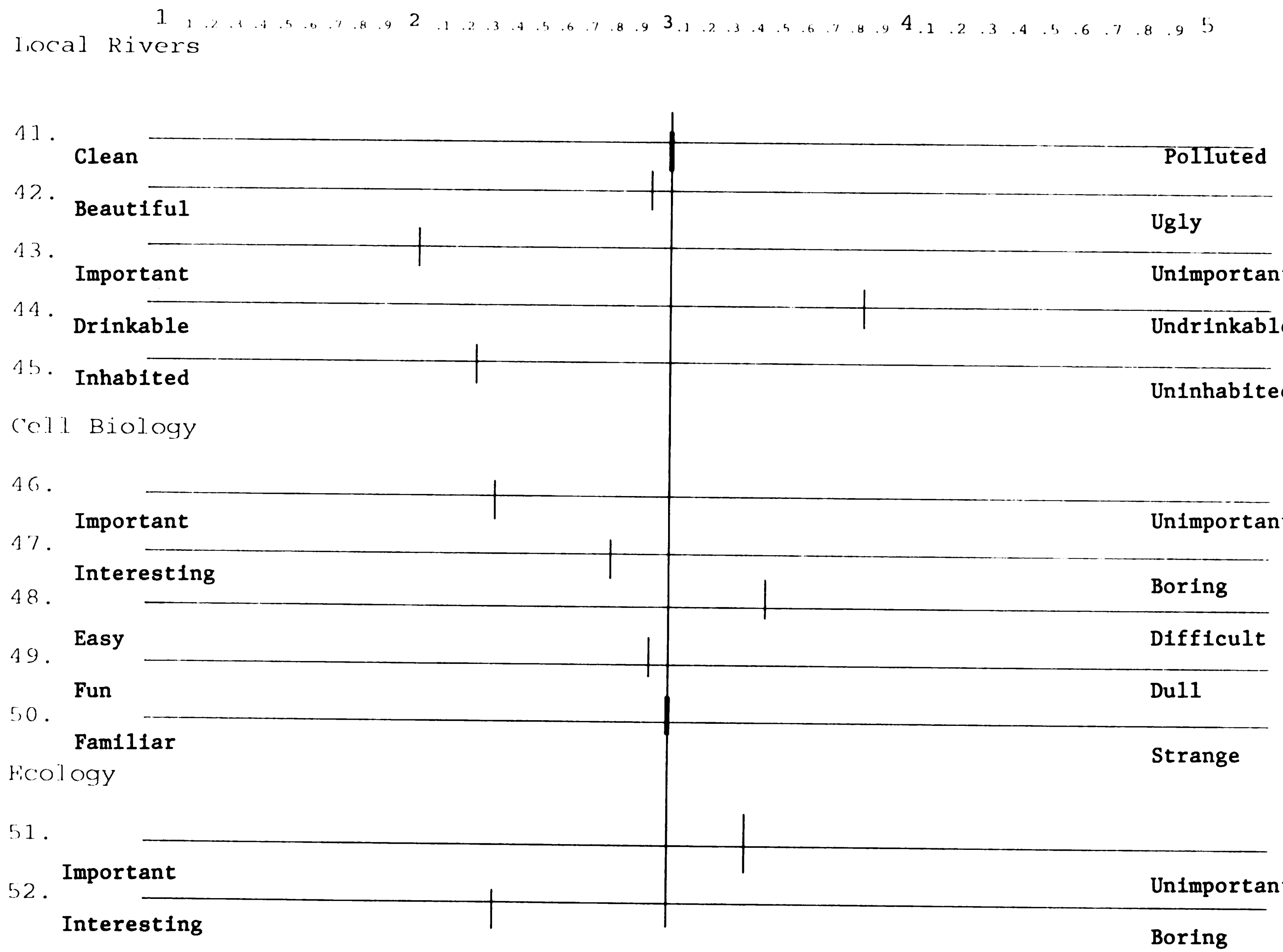
Water Testing
29. Familiar
Strange
30. Good
Bad
31. Important
Unimportant
32. Interesting
Boring
33. Easy
Difficult
34. Necessary
Unnecessary
Recycling
35. Familiar
Strange
36. Good
Bad
37. Fun
Dull
38. Interesting
Boring
39. Easy
Difficult
40. Important
Unimportant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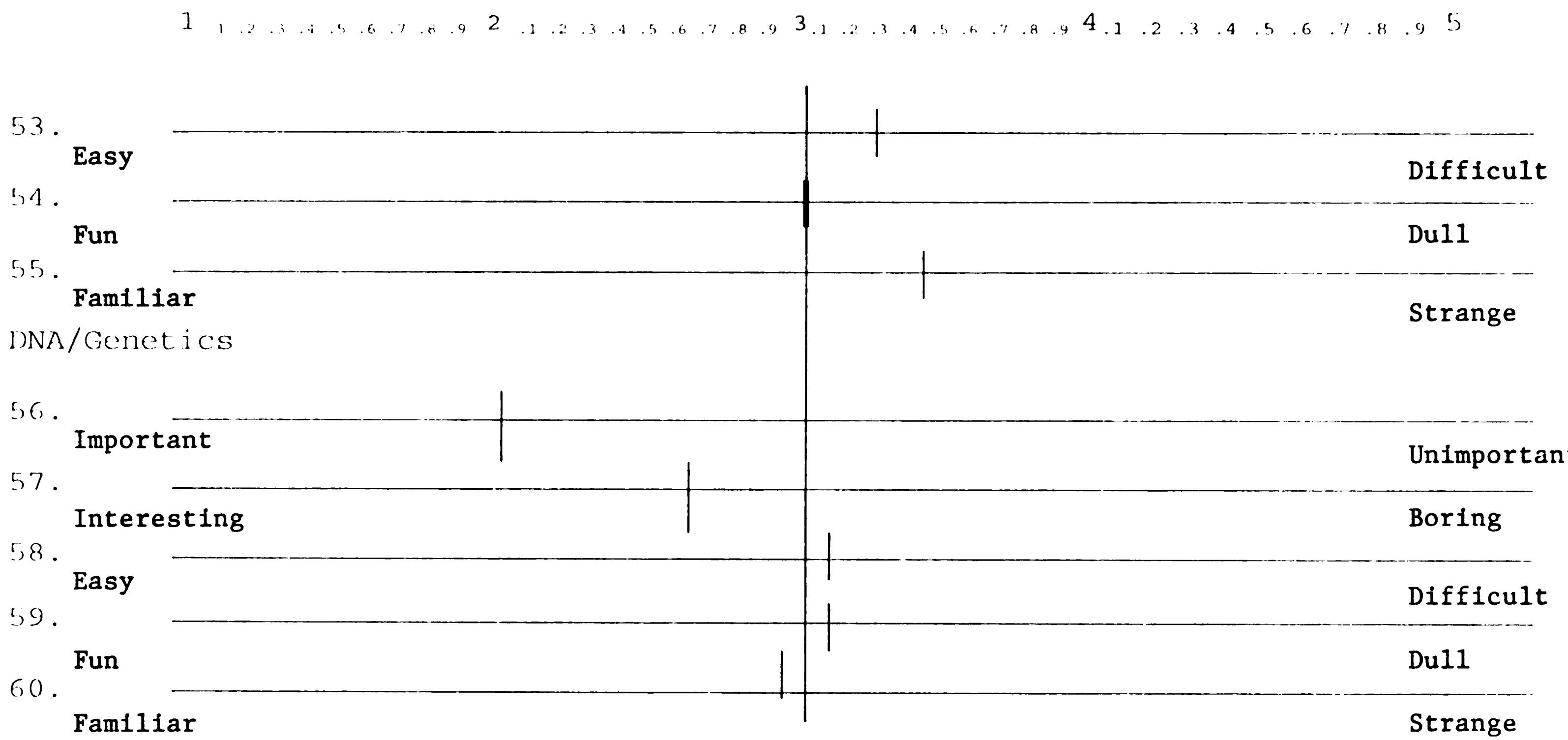
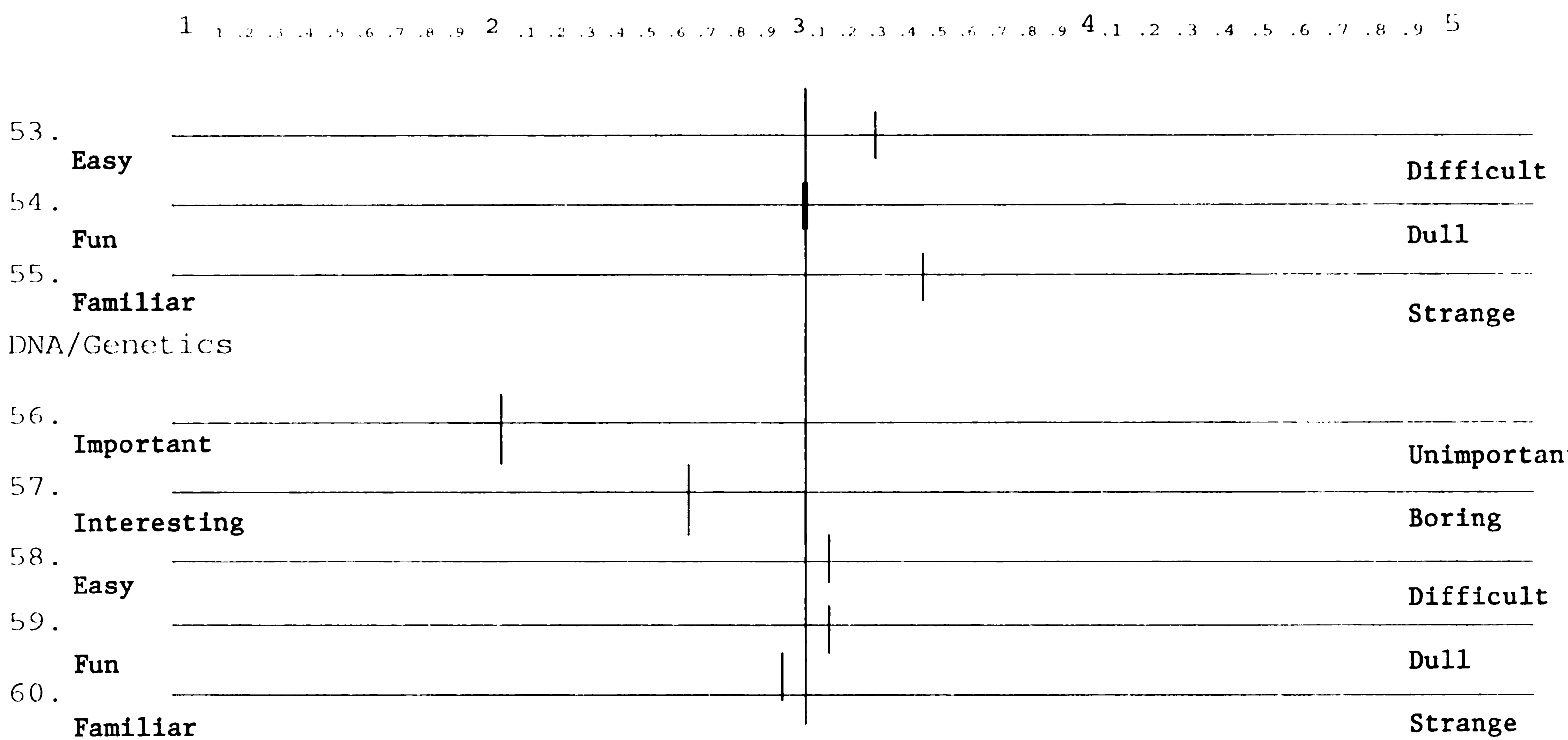
Local Rivers
41. Clean
Polluted
42. Beautiful
Ugly
43. Important
Unimportant
44. Drinkable
Undrinkable
45. Inhabited
Uninhabited
Cell Biology
46. Important
Unimportant
47. Interesting
Boring
48. Easy
Difficult
49. Fun
Dull
50. Familiar
Strange
Ecology
51. Important
Unimportant
52. Interesting
Boring


1 .1 .2 .3 .4 .5 .6 .7 .8 .9 2 .1 .2 .3 .4 .5 .6 .7 .8 .9 3 .1 .2 .3 .4 .5 .6 .7 .8 .9 4 .1 .2 .3 .4 .5 .6 .7 .8 .9 5
53. Easy Difficult
54. Fun Dull
55. Familiar Strange
DNA/Genetics
56. Important Unimportant
57. Interesting Boring
58. Easy Difficult
59. Fun Dull
60. Familiar Strange


1 .1 .2 .3 .4 .5 .6 .7 .8 .9 2 .1 .2 .3 .4 .5 .6 .7 .8 .9 3 .1 .2 .3 .4 .5 .6 .7 .8 .9 4 .1 .2 .3 .4 .5 .6 .7 .8 .9 5
53. Easy
Difficult
54. Fun
Dull
55. Familiar
Strange
DNA/Genetics
56. Important
Unimportant
57. Interesting
Boring
58. Easy
Difficult
59. Fun
Dull
60. Familiar
Strange

A question about laboratory activities (number 11) asked if they were interesting (1) or boring (5). The average answer was 2.4(see table 4). Of the seventy questions presented to the students they answered positively on 41, which is 59%. Under the biology section, students answered positively to five of the seven questions, which is 71% (see table 5). Students answered 100% of the laboratory activity questions with positive responses (see table 5).

Table 5: Number of positive responses to attitude survey questions.

Topic Area	Number of Positive Responses (1 - 2.9)	Number of Negative Responses (3 - 5.0)	Percent of Positive Responses
Biology	5	2	71%
Laboratory activities	7	0	100%
Working in Teams to Solve Problems in Class	6	1	86%
Scientific Method	4	3	57%
Water Testing	4	2	66%
Recycling	5	1	83%
Local Rivers	3	2	60%
Cell Biology	3	2	60%
Ecology	1	4	20%
DNA/Genetics	3	2	60%

Chapter 4

Discussion

In this study, the question whether students learned when a particular technology (computer probes) and a constructivist approach were used was answered. The significant increase (as indicated by the t-test) of forty percent between the pre-test and post-test shows that the students learned a fair amount about water quality. With these results it is clear that this type of instruction could be used successfully in other biology classes and units.

Teacher observations showed that the students really enjoyed the laboratory-based classroom setting. They responded positively when asked how they felt about the class. For example, students said,

- "I feel the lab activities helped me understand the material more than if I was sitting in a chair listening and taking notes".
- "I have a much better understanding of Water Quality since we got to go into the lab and actually perform the tests."
- "I really enjoyed using the calculator and CBL2 in the laboratory.
- "I liked the fact we received a copy of the notes before the lecture. It allowed me to keep up and pay attention to what you were saying."

- "I liked working with other students in the labs and on the projects. It helped us work our way through the labs."

- "I did not like the water quality unit, I don't see why I need to know these tests, and I will never use them again".

This comment is a typical negative comment given by students. This was the only negative comment given by the students. The students' operation of the probes was better than I expected in the lab activities. There was some concern going into the unit that the directions to the labs and probes were too complicated, but the students worked diligently and successfully on the labs. Some students needed to spend time during lunch and/or after school to either repeat or finish a lab or for extra practice time with the probes.

The students showed the greatest improvement in knowledge about the acceptable levels of chemicals and or contaminants in the water. For example, question number four on the pre- and post-test asked for the range of fecal coliform per 100ml of water for drinking. On the Pre-test only 13% of the students answered the question adequately while on the post-test 75% of the students answered the question adequately. Responses to the four essay questions showed a tremendous level of improvement. However, responses to a question about sources of chloride ions showed a lack of understanding after instruction. The only thing that can explain this is inadequate time spent on discussing rocks and substrates as sources of ions. The answer given most often was water running over granite in the ground. Since geology is a follow-up class to Biology One, the students have not had previous instruction on this topic.

The leaf packs helped give the students practice in learning the scientific names of the microorganisms. Not only did they get a lot of repetition with each organism, they got to see the actual organism and not simply a picture or diagram. Many students commented on the fact that they never knew how many microorganisms there were in the water. Others commented on how cool it was to find out the niche some of these organisms hold in their environment.

There are a few aspects of the unit that can be improved in the future. There simply was inadequate equipment for labs. Presently, there are only one or two probes for each test. The instructor did apply and receive a grant from Best Buy to correct this problem. A second problem is the preparation time needed before the class. Setting up for this unit required approximately an hour per day. This can be corrected as the unit is taught more and the instructor gains experience. A third problem in the unit is the large number of students (32) in the class. As all teachers know, it is hard to complete a lab-based unit when you don't have enough lab stations for the students. Finally, the last problem experienced in the unit is the short class periods. It is hard to set up the equipment and then complete the labs and take care of the equipment in 45 minutes. Again this will be partially alleviated as the instructor gains experience and teaches this unit again. This unit was well worth the extra time and work needed to prepare for it. The unit worked in getting the students motivated and interested in their learning. I plan on using the computer probes again not only in biology, but other science classes as well.

APPENDICES

APPENDIX A

Pre-Tests and Post-Tests

Water Quality Unit Pre Test   Name: ______________

_____1. The absence of oxygen in water is a sign of
a. Good quality water.
b. Severe Pollution
c. Very little sun getting to water
d. Cold water

_____2. Levels of dissolved oxygen in water tend to
a. Fluctuate throughout the day
b. Stay the same throughout the day
c. Decrease in the morning and afternoon
d. Peak at midnight.

_____3. Which of the following is not a factor contributing to changes in dissolved oxygen levels?
a. Water temperature
b. Volume of water moving down river
c. Build up of organic waste
d. PH of the water.

_____4. What is the range of fecal coliform per 100mL of water for drinking water?
a. 1-2 colonies
b. 2-3 colonies
c. 3-4 colonies
d. > 4 colonies
e. 0 colonies

____5. Why do we test for Fecal coliform instead of pathogens?
a. Pathogens are too big
b. There are too many pathogens in the water
c. Pathogens are relatively scarce in water
d. Fecal coliform is too disgusting

____6. Which of the following does not control the speed of a river's current?
a. Depth
b. The slope or steepness of the land
c. How much agricultural land is on the river
d. The width of the stream channel
e. The roughness of the river bottom

____7. How have some invertebrates evolved to meet the challenges of living in a river current during a flood?

a. Swim upstream
b. Swim downstream
c. Burrow into the substrate
d. Develop suckers on their legs to stick to the rocks.

____8. Nitrogen is used by all plants and animals to

a. Digest food
b. Build Proteins
c. Breathe
d. Degenerate amino acids

____9. An increase in water temperature caused by adding relatively warm water to a body of water is referred to as

a. Solar energy
b. Thermal Pollution
c. Discharge
d. Unsafe

____10. The concentration of what two ions determines pH?

a. H^- and OH^-
b. H^+ and OH^+
c. H^+ and OH^-
d. H^- and OH^+

____11. Which of the following is not a source of Chloride ions?

a. Runoff from salted roads.
b. Water softener regeneration
c. Irrigation water returned to streams
d. Water running over granite in the ground

True and False

____12. Some rivers can have so low amounts of dissolved oxygen that they are almost empty of aquatic life.

____13. Pike and trout prefer low levels of dissolved oxygen

____14. Mayfly nymphs, stonefly nymphs, and caddis fly larvae cannot tolerate high levels of dissolved oxygen.

____15. Fecal Coliform themselves are not pathogenic.

____16. The life cycles of many aquatic insects are closely tied to seasonal water temperatures.

____17. Many aquatic insects will not hatch their eggs if thermal cues are present.

____18. Water temperatures in the lower reach of a river generally fluctuate more than in the midreach.

____19. Discharge is a measure of the volume of water passing a given point over a given period of time.

20. Draw a graph showing the relationship of amounts of dissolved oxygen vs. time of day. Be sure to label your graph properly. (Rubric C)

21. List four significant factors that affect the distribution and relative abundance of aquatic insects in a stream. (Rubric A)

22.Describe two examples of macro-invertebrates evolving to live in the current of a river. (Rubric B)

23.John and Angie went fishing one hot summer day. Angie let her fishing line hang several meters deeper in the river than John. She caught her limit of fish, while he caught only one catfish. Offer an hypothesis as to why Angie caught more fish than John. How would you test to prove that hypothesis? (Rubric A)

Water Quality Unit Post-Test Name: ________________

Directions: Choose the best answer for each question. Please write your answer on the line provided. Be sure to use capital letters.

_____1. What does CBL2 stand for?
a. Computer biased learning.
b. California balanced learning.
c. Calculator based learning.
d. Cable TV for two.

_____2. The optimal temperature range (°C) for mayfly larvae is
a. 5-20
b. 5-28
c. 10-25
d. 20-25

_____3. Which one of the following is not a reason for temperature to rise in rivers?
a. Warming of the ground
b. Water runoff from parking lots
c. Cutting trees down around the river
d. Thermal pollution

_____4. The absence of oxygen in water is a sign of
e. Good quality water.
f. Severe Pollution
g. Very little sun getting to water
h. Cold water

_____5. Much of the dissolved oxygen in water comes from
a. The ground
b. Algae and rooted plants
c. The atmosphere
d. Aquatic organisms

_____6. Levels of dissolved oxygen in water tends to
e. Fluctuate throughout the day
f. Stay the same throughout the day
g. Decrease in the morning and afternoon
h. Peak at midnight.

_____7. Which of the following is not a factor contributing to changes in dissolved oxygen levels?
e. Water temperature

f. Volume of water moving down river
g. Build up of organic waste
h. PH of the water.

_____8. Which of the following would not be considered organic waste?
a. Feces
b. Rocks
c. Leaves
d. Food

_____9. Where would you find the source for fecal coliform?
a. Rain water runoff from a roof.
b. Feces of humans and other warm blooded animals.
c. Blood from warm-blooded animals.
d. None of the above is a source for fecal coliform.

____10. What does Pathogenic mean?
a. Disease Causing
b. Deadly
c. To follow a path
d. Term used to describe the path a river or stream would take.

____11. What is the range of fecal coliform per 100mL of water for drinking water?
f. 1-2 colonies
g. 2-3 colonies
h. 3-4 colonies
i. > 4 colonies
j. 0 colonies

____12. Which of the following are not diseases that can be contracted by swimming in water with colifrom counts above 200 colonies?
a. Typhoid fever
b. Influenza
c. Ear Infection
d. Gastroenteritis

____13. Why do we test for Fecal coliform instead of pathogens?
e. Pathogens are too big
f. There are too many pathogens in the water

g. Pathogens are relatively scarce in water
h. Fecal coliform is too disgusting

____14. Warmer water temperatures usually cause a(n) __________________ in the growth rate of aquatic organisms.
a. increase
b. decrease
c. both
d. neither

____15. Which of the following does not control the speed of a river's current?
f. Depth
g. The slope or steepness of the land
h. How much agricultural land is on the river
i. The width of the stream channel
j. The roughness of the river bottom

____16. The current is fastest just beneath the water surface because
a. Friction is decreased between the air and surface water.
b. There are less plants to slow the water down.
c. The riverbed does not slow the water down here.
d. None of the above, the current is the same everywhere.

____17. As water becomes deeper the velocity is _______________.
a. Increased
b. Decreased
c. Relatively the same
d. None of the above

____18. How have some invertebrates evolved to meet the challenges of living in a river current during a flood?
e. Swim upstream
f. Swim downstream
g. Burrow into the substrate
h. Develop suckers on their legs to stick to the rocks.

____19. Nitrogen is used by all plants and animals to
e. Digest food
f. Build Proteins
g. Breathe
h. Degenerate amino acids

____20. Which is the most abundant gas in the air we breathe?

a. Oxygen
b. Carbon Dioxide
c. Hydrogen
d. Nitrogen

____21. Too much nitrogen in a water environment can cause it to become

a. Oligotrophic
b. Mesotrophic
c. Eutrophic
d. None of the above

____22. Which of the following is not a source of nitrates in water is

a. Fertilizers
b. Runoff from cattle feedlots
c. Feces from ducks and geese
d. Runoff from barnyards
e. All of the above are sources of nitrates in water

____23. Soil erosion can be caused by all of the following except

a. Removal of streamside vegetation
b. Increased water temperature
c. Overgrazing
d. Poor farming practices
e. Construction

____24. Cool water can hold _________ dissolved gases than warm water.

a. More
b. Less
c. The same

____25. An increase in water temperature caused by adding relatively warm water to a body of water is referred to as

e. Solar energy
f. Thermal Pollution
g. Discharge
h. Unsafe

____26. The concentration of what two ions determines pH?

e. H^- and OH^-

f. H^+ and OH^+
g. H^+ and OH^-
h. H^- and OH^+

____27. A pH of 8 is a
a. acid
b. base
c. neutral
d. none of the above

____28. Which of the following is not a source of Chloride ions?
e. Runoff from salted roads.
f. Water softener regeneration
g. Irrigation water returned to streams
h. Water running over granite in the ground

____29. What is the range of total solids found in rivers?
a. 10-20 mg/L
b. 20-100 mg/L
c. 20-500 mg/L
d. 100-500 mg/L

True and False
Directions: If using a scan tron sheet please mark (a) for true and (b) for false. If writing the answers on the test, please use capital letters.

____30. Some rivers can have so low amounts of dissolved oxygen that they are almost empty of aquatic life.

____31. Pike and trout prefer low levels of dissolved oxygen

____32. Catfish and carp prefer high levels of dissolved oxygen

____33. Water temperature and the volume of water moving down a river affect dissolved oxygen levels.

____34. Depletions in dissolved oxygen can cause a major shift in the kinds of aquatic organisms found in water bodies.

____35. Mayfly nymphs, stonefly nymphs, and caddis fly larvae cannot tolerate high levels of dissolved oxygen.

____36. Fecal Coliform themselves are not pathogenic.

____37. Fecal Coliform bacteria occur naturally in the human digestive tract and aid in the digestion of food.

____38. The correlation between fecal coliform and the probability of contacting a disease from the water is very good.

____39. The life cycles of many aquatic insects are closely tied to seasonal water temperatures.

____40. Many aquatic insects will not hatch their eggs if thermal cues are present.

____41. Water temperatures in the lower reach of a river generally fluctuate more than in the midreach.

____42. Discharge is a measure of the volume of water passing a given point over a given period of time.

____43. Velocity of a river depends on the type of substrate.

____44. Gravel and rock bottom rivers will have a faster velocity than sand or silt bottoms.

____45. Sludge worms, and leeches are examples of pollution tolerant organisms.

____46. Diversity refers to the number of the same type of organism found in a biological community.

____47. Nitrogen is less abundant than phosphorus in nature.

____48. Sewage is the main source of nitrates added by humans to rivers.

____49. Methemoglobinemea is also referred to as blue baby syndrome.

____50. Temperature directly affects the physical, biological, and chemical characteristics of a river.

____51. Temperature does not affect the metabolic rates of aquatic organisms.

____52. People have affected the temperature of water by cutting down trees.

____53. Soil erosion can contribute to warmer waters.

____54. As water temperature rises the rate of photosynthesis decreases.

____55. High levels of total dissolved solids can affect pH levels.

____56. Total dissolved solids include the suspended and dissolved solids.

Essay Questions

Directions: Answer these questions as completely as possible.

57. Draw a graph showing the relationship of amounts of dissolved oxygen vs. time of day. Be sure to label your graph properly.

58. List four significant factors that affect the distribution and relative abundance of aquatic insects in a stream.

59. Draw a line graph showing the relationship between temperatures and growth rate of most aquatic insects. Be sure to label your graph properly.

60. List the four factors that control a river currents speed.

1.
2.
3.
4.

61. Describe two examples of macro-invertebrates evolving to live in the current of a river.

62. Describe how macro-invertebrates can be used to evaluate water quality.

63. Describe how a septic system works. Trace water from your bathtub to the well.

64. John and Angie went fishing one hot summer day. Angie let her fishing line hang several meters deeper in the river than John. She caught her limit of fish, while he caught only one catfish. Offer a hypothesis as to why Angie caught more fish than John. How would you test to prove that hypothesis?

65. List the fecal coliform standards for drinking water and for swimming water.

66. In your own words, what is dissolved oxygen, and why is it important in aquatic habitats?

Matching: Match the picture to the macro-invertebrate names listed. Please use capital letters so there is absolutely no confusion on what letter you are choosing.

______67. Alderfly

______68. Dobsonfly

______69. Caddisfly

______70. Mayfly

______71. Stonefly

______72. Crane fly

______73. Black Fly Larvae

______74. Midge

______75. Blood Worm Midge

______76. Crayfish

______77. Sow bugs

______78. Leech

______79. Damselfly

______80. Dragonfly

______81. Water Penny

______82. Planarians

______83. Water Striders

______84. Riffle Beetle

______85. Scud

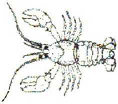

A.


B.


C.


D.


E.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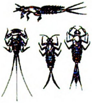
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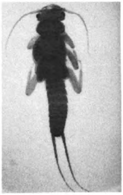

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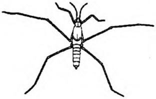

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APPENDIX B

Laboratory Activities

Student Lab #1: Temperature

Lab taken from Water Quality With Calculators From Vernier

Objective

- To teach students there is a difference in temperatures between streams.
- To teach students how to use a CBL2 and Vernier probe to take temperature readings.

Overview

Aquatic organisms require an optimum water temperature in order for them to live there. Water temperatures outside of the normal range for aquatic organisms can severely harm those organisms. (Table 1 shows the optimal temperature ranges for some water organisms.)

There are many factors that can lead to changes in water temperature. Thermal pollution, which is caused by human activity, is one of these factors. Water is used by many industries in processes to create a product. Water is collected, used, and then returned to the source further down stream. The water is usually treated before being returned to the river causing the temperature of the water to be hotter than that of the river it is being returned to. A second factor that causes temperature changes is the amount of runoff collected in the stream. Runoff from parking lots, and roofs is much warmer than the stream, which in turn increases the overall temperature of the stream. The amount of shade on a stream can influence the overall water temperature as well. Humans have been known for destroying the trees along a stream, which will allow a greater amount of light to hit the water, which increases the overall temperature.

So the question is, why does it matter how hot the river water is? The most important aspect of water temperature is its effect on the solubility of gases. More gas can be dissolved at lower temperatures than at higher temperatures. Could we test this statement in the lab? Increased water temperature can also cause an increase in the photosynthetic rate of the water plants and algae. By increasing the photosynthetic rate of water plants it causes increased plant growth and algal blooms, which can be harmful to the ecosystem.

Table 1: Optimal Temperature Ranges For Some Aquatic Organisms.

Organism	Temperature Range (°C)
Trout	5-20
Small mouth Bass	5-28
Caddisfly Larvae	10-25
Mayfly Larvae	10-25
Stonefly Larvae	10-25
Water Boatmen	10-25
Carp	10-25
Mosquito	10-25
Catfish	20-25

Summary of Methods

You will use a temperature probe to measure the temperature of the water at one site and at a second site. (One site above the water treatment plant and the second site below the water treatment plant.)

Materials Checklist

CBL2 Interface
TI-83+ Calculator
DataMate Program
Temperature Probe (Vernier)

Collection and Storage of Samples

1. Water temperature must be collected on site by either placing the probe directly in the stream or by collecting a sample and immediately measuring its temperature.
2. If you need to collect a sample on site and test it on the shore it is important to obtain the water sample from below the surface of the water and as far away from shore as is safe.

Testing Procedure

1. Plug the temperature probe into Channel 1 of the CBL2 interface. Use the link cable to connect the TI graphing Calculator to the interface. Firmly press in the cable ends.
2. Turn on the calculator and start the DATAMATE program. Press clear to reset the program.
3. Set up the calculator and interface for the correct temperature probe.
   a. Select setup from the main menu
   b. If the calculator displays the correct temperature probe in CH. 1, proceed directly to step 4. If it does not, continue with this step to set up your sensor manually.
   c. Press enter to select CH. 1
   d. Select temperature from the select sensor menu
   e. Select the correct temperature probe (in °C) from the menu. (Stainless steel °C)
4. Set up the data-collection mode
   a. To select Mode press the up arrow once and press enter.
   b. Select single point from the select mode menu.
   c. Select ok to return to the main screen.
5. Collect Temperature data.
   a. Place the tip of the temperature probe directly into the stream at Site 1 (or in the cup containing a sample from site 1). Make sure the probe is approximately 10cm deep and hold for 30 seconds.
   b. Select start to begin sampling. It is important to leave the probe tip in the water while sampling.
   c. After 10 seconds the temperature value will appear on the screen. Record this value on the Data sheet. (Round to the nearest .1°C).
   d. Press enter to return to the main screen
   e. Select start to obtain a second reading. Record this value on the Data sheet. (Round to the nearest 0.1°C).
   f. Press enter to return to the main screen.
6. Repeat steps 1-5 at Site 2.

TEST #1: TEMPERATURE

DATA COLLECTION SHEET

STREAM NAME___________________

DATE_________________________

SITE NUMBER____________________

TIME__________________________

RESEARCHER NAME____________________________________

Problem:

____

____

____

Hypothesis:

____

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DIRECTIONS: RECORD TEMPERATURE IN THE FOLLOWING TABLE. ROUND ALL TEMPERATURES TO THE NEAREST TENTH (0.1) DEGREE.

SITE NUMBER	TEMPERATURE 1 (°C)	TEMPERATURE 2 (°C)	AVERAGE (°C)	TEMPERATURE DIFFERENCE (°C)
1 UPSTREAM				
2 DOWNSTREAM				
T value				

- AVERAGE IS FOUND BY ADDING BOTH TEMPERATURES FOR A SITE AND DIVIDING BY TWO.

- TEMPERATURE DIFFERENCE = AVERAGE TEMPERATURE SITE 1 - AVERAGE TEMPERATURE SITE 2.

OBSERVATIONS FROM FIELD (VEGETATION ALONG STREAM, WEATHER, AND
GEOGRAPHY. ____

Conclusion Questions

Directions: Please answer each question to the best of your ability. If you answer these questions with less than 10 words you most likely are wrong. Additional research in the library or on the Internet may be required to answer these questions.

1. Should there be a difference in average water temperature between the two streams? Why?

2. Did you except your hypothesis or reject your hypothesis? Why?

Student Lab #2: pH Test

Taken from Water Quality with Calculators by Vernier

Objectives

- To teach students that streams have different pHs.
- To teach students factors that affect the pH of a stream.
- To tech students how to take pH readings using a CBL2 and Vernier probe.

Overview

Water contains two types of ions, hydrogen ions H+, and hydroxide ions OH^-. The concentration of these two ions determines the pH value. The pH value can be calculated by using the formula $pH=-log[H^+]$. Water with a pH value of 7 has an equal concentration of these two ions and is considered to be a neutral solution. If a solution has a greater concentration of H^+ ions it is considered acidic. If a solution has a greater concentration of OH^- ions it is considered a basic solution. The pH scale is a 0-14 scale with a value of 0 being the most acidic and a value of 14 the most basic. A change from pH of 7 to a pH of 8 in a stream represents a ten-fold increase in the OH^- ion concentration.

Rainfall generally has a pH value between 5 and 6.5 (which means there is a greater number of H^+ ions). It is acidic because of the dissolved carbon dioxide and air pollutants, such as sulfur dioxide or nitrogen oxides. If the rainwater flows over soil containing hard-water minerals, its pH usually increases.

Measuring the pH of a body of water is important as an indication of water quality, because of the sensitivity of aquatic organisms to the pH of their environment. Small changes in pH can severely affect many of the aquatic organisms found in most streams and lakes. See table 1 for the effects of pH levels on aquatic organisms.

Table 1. Effects of pH levels on Aquatic life.

PH	Effect
3.0-3.5	Unlikely that fish can survive for more than a few hours in this range, there are some exceptions.
3.5-4.0	Known to be lethal to salmonids
4.0-4.5	All fish, most frogs, insects absent
4.5-5.0	Mayfly and many other insects absent. Most fish eggs will not hatch.
5.0-5.5	Bottom dwelling bacteria (decomposers) begin to die. Accumulation of detritus. Plankton disappears. Snails and clams absent.
6.0-6.5	Freshwater shrimp absent. Unlikely to be directly harmful to fish.
6.5-8.2	Optimal for most organisms
8.2-9.0	Unlikely to be directly harmful to fish, but indirect effects occur at this level due to chemical changes in the water.
9.0-10.5	Likely to be harmful to salmonids and perch if present for long periods.
10.5-11.0	Rapidly lethal to salmonids. Prolonged exposure lethal to carp, perch.
11.0-11.5	Rapidly lethal to all species of fish.

Changes in pH can also be caused by industrial processes resulting in a release of acids and bases, or the oxidation of sulfide-containing sediments. See table 2 for more factors that affect pH levels. In the United States and Eastern Canada, fish populations in some lakes have been significantly lowered due to the acidity of the water caused by acid rain. If the water is very acidic, heavy metals may be released into the water and can accumulate on the gills of fish or cause deformities that reduce the likelihood of survival. In some cases, older fish will continue to live, but will be unable to reproduce because of eh sensitivity of the reproductive portion of the growth cycle.

Table 2: Factors that affect pH levels in lakes and streams.

* Acidic rainfall
* Algal blooms
* Level of hard-water minerals
* Releases from industrial processes
* Carbonic acid from respiration or decomposition

* Oxidation of sulfides in sediments

Summary of Methods

You will use a pH probe connected to a CBL2 interface to make either on-site measurements or in the lab measurements using previously collected water.

Materials Checklist

CBL2 interface
TI-83+ calculator
DataMate program
Vernier pH sensor
pH buffer solution 7 and 10
Distilled water
250mL beaker

Collection and Storage of Samples

1. This test can be conducted on site or in the lab. A 100mL sample is required if conducting in the lab.
2. It is important to obtain the water sample from below the surface of the water and as far away from shore as is safe.
3. If the testing cannot be conducted within a few hours, store samples in an ice chest or refrigerator.

Testing Procedure

1. Plug the pH sensor into channel 1 of the CBL2 interface. Use the link cable to connect the TI-83+ calculator to the interface. Firmly press in the cable ends.
2. Turn on the calculator and start the DATAMATE program. Press clear to reset the program.
3. Set up the calculator and interface for the pH sensor.
   a. Select setup from the main screen.
   b. If the calculator displays pH in CH. 1, proceed directly to step 4. If it does not, continue with this step to set up your sensor manually.
   c. Press enter to select CH. 1.
   d. Select pH from the select sensor menu.

4. Set up the calibration for the pH sensor.
   a. Select calibrate, and then calibrate now.

b. Remove sensor from bottle and rinse sensor with distilled water.
c. Place the sensor into pH-7 buffer. Wait for the voltage to stabilize, then press enter.
d. Enter "7" on the calculator
e. Rinse the pH sensor with distilled water and place it in the pH-10 buffer solution
f. Wait for the voltage to stabilize, then press enter.
g. Enter "10" on the calculator
h. Select OK to return to the setup screen.

5. Set up the data-collection mode
    a. To select mode, press the up arrow once and press enter.
    b. Select single point from the select mode menu.
    c. Select OK to return to the main screen.

6. Collect pH data
    a. Remove the pH sensor from the storage bottle. Rinse the tip of the sensor thoroughly with the stream water.
    b. Place the tip of the sensor into the stream (or cup). Submerge the sensor tip in the stream or in a cup to a depth of 3-4 cm.
    c. When the readings stabilize, select start to begin sampling. Make sure to leave the probe in the water while collecting data.
    d. After 10 seconds the pH value will appear on the calculator screen. Record this value on the pH test data sheet (round the value to the nearest .01 pH units).
    e. Press enter to return to the main screen.
    f. Select start to repeat the measurement. Record this value on the data collection sheet (round the value to the nearest .01 pH units).
    g. Press enter to return to the main screen.
    h. Repeat step 6 at site two.
    i. Rinse the sensor with distilled water and return it to the storage bottle when you have finished collecting your data.

TEST #2: Ph

DATA COLLECTION SHEET

STREAM NAME____________________ DATE___________________________

SITE NUMBER_____________________
TIME____________________________

RESEARCHER NAME_______________________________________

Problem:

____
____
____

Hypothesis:

____
____
____

DIRECTIONS: RECORD pHs IN THE FOLLOWING TABLE. ROUND ALL pHs TO THE NEAREST TENTH (.1) DEGREE.

SITE NUMBER	pH 1	pH 2	AVERAGE	pH DIFFERENCE
1 Site 1				
2 Site 2				
T value				

- AVERAGE IS FOUND BY ADDING BOTH pHs FOR A SITE AND DIVIDING BY TWO.
- pH DIFFERENCE = AVERAGE pH SITE 1 - AVERAGE pH SITE 2.

OBSERVATIONS FROM FIELD (VEGETATION ALONG STREAM, WEATHER, AND GEOGRAPHY. ____

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Conclusion Questions

Directions: Answer these questions to the best of your ability. You may have to perform some additional research in the library or at home to answer some of these questions.

1. Would you expect there to be a difference in the pH value between the two sites? Why?

2. If the pH of site 1 was 7.8 and the pH of site 2 was 6.8, what does this mean in terms of ions?

3. Did you except or reject your hypothesis? Why?

Student Lab #3: Chloride

Taken from Water Quality with Calculators by Vernier

Objectives

- To teach students that streams differ in amounts of Chloride ions.
- To teach students factors that affect chloride ions in streams.
- To teach students how to take Chloride readings using a CBL2 and vernier probe.

Overview

One of the major inorganic negative ions (anions) in saltwater and freshwater is Chloride in the form of the Cl^- ion. This ion comes from the breaking apart of salts, such as sodium chloride or calcium chloride, in water. These salts originate from natural minerals, saltwater intrusion, into estuaries, and industrial pollution.

Table 1: Sources of Chloride Ions
• River streambeds with salt-containing minerals • Runoff from salted roads • Irrigation water returned to streams • Mixing of seawater with freshwater • Water softener regeneration

There are many possible sources of manmade salts that may contribute to elevated chloride readings (table 1). Sodium chloride and calcium chloride, used to salt roads, contribute to elevated chloride levels in streams. Chlorinated drinking water and sodium chloride water softeners often increase chloride levels in wastewater of a community.

In drinking water, the salty taste produced by chloride depends upon the concentration of the chloride ion. The recommended maximum level of chloride in U.S. drinking water is 250 mg/L.

Expected Levels

Freshwater streams and lakes have a significant chloride level that can range from 1 to 250mg/L.

Summary of Methods

A Vernier Chloride Ion-Selective Electrode is used to measure the chloride ion concentration in the water (in mg/L) either on site or after returning to the lab.

Materials Checklist

CBL2 interface
TI-83+ graphing calculator
Datamate program
Chloride Ion-Selective Electrode
Distilled water
Low standard (10 mg/L Cl^-)
High standard (1000 mg/L Cl^-)

Collection and Storage of Samples

1. This test can be conducted on site or in the lab. A 100 mL sample is required.
2. It is important to obtain the water sample from below the surface of the water and as far away from shore as possible.

Testing Procedure

1. The Vernier Chloride Ion-Selective Electrode (ISE) must be soaked in the Chloride High Standard solution for approximately 30 minutes. Make sure the ISE is not resting on the bottom, and that the small white reference contacts are immersed. Make sure there are no air bubbles trapped below the ISE.
2. With the ISE still soaking in the High Standard solution, plug it into channel 1 of the CBL2 interface. Use the link cable to connect the TI-83+ calculator to the interface. Firmly press in the cable ends.
3. Turn on the calculator and start the datamate program. Press clear to reset the program.
4. Set up the calculator and interface for the ISE
   a. Select setup from the main screen
   b. If the calculator displays CL ISE (MG/L) in CH 1 proceed directly to step 5. If it does not, continue with this step to set up your sensor manually.
   c. Press enter to select CH. 1.
   d. Select Ion selective from the select sensor menu.
   e. Select CL ISE (MG/L) from the Ion selective menu.

5. Set up the calibration for the chloride ISE
    a. Select Calibrate, then Calibrate now
    b. When the voltage reading is stable press enter
    c. Enter "1000" as the concentration of the standard in mg/L Cl^-
    d. Rinse the ISE thoroughly with water and gently blot it dry with a tissue or paper towel. Be very careful when blotting membrane.
    e. Place the tip of the ISE into the low standard. Be sure that the ISE is not resting on the bottom of the bottle and that the small white reference contacts are immersed. Make sure there are no air bubbles trapped below the ISE.
    f. After briefly swirling the solution, hold the ISE still and wait approximately 30 seconds for the voltage reading to stabilize press enter.
    g. Enter "10" as the concentration of the standard in mg/L Cl^-
    h. Select OK to return to the setup screen

6. Set up the data collection mode
    a. To select mode press the up arrow once and press enter.
    b. Select single point from the select mode menu
    c. Select OK to return to the main screen.

7. Collect chloride concentration data
    a. Rinse the ISE with distilled water and gently blot dry with a tissue or paper towel. Place the tip of the ISE into the stream at Site 1, or into a cup containing the water sample from site 1. Make sure the small white reference contacts are immersed, and that the ISE is not resting on the bottom of the cup. Be sure no air bubbles are trapped below the ISE.
    b. After briefly swirling the solution, hold the ISE still and wait approximately 30 seconds for it to stabilize.
    c. Select start to begin sampling. Hold the ISE still for the next 10 seconds.
    d. After 10 seconds the chloride concentration will appear on the screen. Record this value on the Data sheet rounding to the nearest 0.01mg/L Cl^-.
    e. Press enter to return to the main screen
    f. Select start to obtain a second reading. Record this value on the data sheet as well.
    g. Press enter to return to the main screen

TEST #3: Chloride Concentration

DATA COLLECTION SHEET

STREAM NAME__________________ DATE__________________________

SITE NUMBER____________________ TIME___________________________

RESEARCHER NAME_______________________________________

Problem:

____
____
____

Hypothesis:

____
____
____

Reading	Site 1 Chloride ($mg/L\ Cl^-$)	Site 2 Chloride ($mg/L\ Cl^-$)
1		
2		
Average		
T value		

OBSERVATIONS FROM FIELD (VEGETATION ALONG STREAM, WEATHER, AND
GEOGRAPHY.____
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Conclusion Questions

Directions: Answer the following questions as completely as possible. Additional information from the library or Internet may be needed.

1. Would you expect there to be a difference in chloride between the two sites? Why?

2. Now that you have the data what do they mean?

3. What is the purpose of doing a t-test with this lab?

4. Did you accept or reject your hypothesis? Why?

Student Lab #4: Dissolved Oxygen

Taken from Water Quality with Calculators by Vernier

Objective

- To teach students that dissolved oxygen readings differ between streams.
- To teach students the importance of dissolved oxygen in aquatic environments.
- To teach students how to take dissolved oxygen readings using a CBL2 and a vernier probe.

Overview

Aquatic organisms require oxygen gas dissolved in the water in order to survive. These organisms use the oxygen for processes such as cellular respiration. The amount of dissolved oxygen (DO) in an environment is a great indictor of water quality.

Some organisms such as salmon, mayflies, and trout, require high concentrations of dissolved oxygen. Other organisms such as catfish, mosquito larvae, and carp, can survive in lower concentrations of dissolved oxygen. See table 1 for minimum dissolved oxygen requirements for various aquatic organisms.

A variety of processes produce dissolved oxygen. Diffusion between the atmosphere and water at its surface, aerations as water flows over rocks and other debris, churning of water by waves and wind, and photosynthesis of aquatic plants. There are also many different factors that affect the DO level (see table 2).

There are large fluctuations of DO levels throughout the day. Dissolved oxygen levels will rise in the morning, reaching a peak in the afternoon. In the evening photosynthesis stops, but due to the respiring of plants and animals the DO levels drop. Because of this DO readings should be done around the same time every day.

Table 1: Minimum dissolved oxygen requirements for various aquatic organisms.

Organism	Minimum DO (mg/L)
Trout	6.5
Small Mouth Bass	6.5
Caddisfly larvae	4.0
Mayfly larvae	4.0
Catfish	2.5
Carp	2.0
Mosquito larvae	1.0

Table 2: Factors that affect dissolved oxygen levels.

- Temperature
- Aquatic plant populations
- Decaying organic material in water
- Stream Flow
- Altitude/atmospheric pressure
- Human activities

Temperature is important to the ability of oxygen to dissolve. Oxygen, like all gases, has different solubilities at different temperatures. Cooler waters have a greater capacity for dissolved oxygen than warmer waters. Human activities such as removing foliage along a stream or releasing warm water used in industrial processes can cause an increase in temperature. This results in a lower dissolved oxygen capacity for the stream.

Expected Levels

In this lab we will be using percent saturation of dissolved oxygen for our water quality comparisons. Percent saturation is the dissolved oxygen reading in mg/L divided by the 100% dissolved oxygen value for water at the same temperature and air pressure. The relationship between percent saturation and water quality is found on the attached paper.

Table 3: Levels of Percent saturation of dissolved oxygen.

DO Level	Percent Saturation of DO
Supersaturation	$\geq$101%
Excellent	90-100%
Adequate	80-89%
Acceptable	60-79%
Poor	< 60%

Summary of Methods

We will be using a dissolved oxygen probe and a barometer probe for our readings. These recordings are best taken at the site of the river. Water samples can be collected and stored on ice to be measured in the classroom if needed.

Materials Checklist

CBL2 Interface
TI-83 graphing calculator
DataMate program
Dissolved Oxygen Probe
Barometer
250mL beaker
100% calibration bottle
Distilled water
Sodium Sulfite Calibration Solution
DO Electrode Filling Solution
Pipette

Collection and Storage of Samples

1. Try collecting your sample from as far away from the shore as possible and from under the surface of the water.
2. If you are taking your sample back to the lab make sure there are no air bubbles in the water sample and the container is lightly stoppered. The sample should be stored in an ice chest or refrigerator until measurements can be taken.

Testing Procedure

1. Prepare the dissolved oxygen probe for use.
    a. Unscrew the membrane cap from the tip of the probe.
    b. Using a pipet fill the membrane cap with 1mL of DO Electrode filling solution.
    c. Carefully thread the membrane cap back onto the electrode.
    d. Place the probe into a container of water.

2. Plug the dissolved oxygen probe into channel 1 of he CBL2 interface. Use the link cable to connect the TI-83+ calculator to the interface. Firmly press in the cable ends.
3. Turn on the calculator and start the DATAMATE program. Press clear to reset the program.
4. Set up the calculator and interface for the dissolved oxygen probe.
    a. If CH. 1 displays DO (MG/L) proceed to step 5. If it does not, continue with this step to set up your sensor manually.
    b. Select setup from the main screen.
    c. Press enter to select CH. 1.
    d. Select D. Oxygen (MG/L) from the select sensor menu.
    e. Select ok to return to the main screen.

5. Warm up the dissolved oxygen probe for 10 minutes.
    a. With the probe still in the water, wait 10 minutes while the probe warms up. The probe must stay connected to the interface at all times to keep it warmed up. If disconnected for a period longer than a few minutes, it will be necessary to warm it up again.
    b. Select setup from the main screen.

6. Set up the calibration for the dissolved oxygen probe.
    a. Select calibrate, and then calibrate now.
    b. Remove the probe from the water and place the tip of the probe into the Sodium Sulfite Calibration Solution. Important: No air bubbles can be trapped below the tip of the probe or the probe will sense an inaccurate dissolved oxygen level. If the voltage does not rapidly decrease, tap the side of the bottle with the probe to dislodge the bubble. The readings should be in the 0.2-0.5 volt range.

c. When the voltage stabilizes press enter.
d. Enter "0" as the known value in mg/L.
e. Rinse the probe with distilled water and carefully blot dry.
f. Unscrew the lid of the calibration bottle provided with the probe. Slide the lid and the grommet about ½ inch onto the probe body.
g. Add water to the bottle to a depth of about ¼ inch and screw the bottle into the cap. Important: Do not touch the membrane or get it wet during this step.
h. Keep the probe in this position for a minute. The readings should be above 2.0 V. When the voltage stabilizes, press enter.
i. Enter the correct saturated dissolved oxygen value (in mg/L) from table 4 using the correct barometric pressure and air temperature values.
j. Select ok to return to the setup screen.

7. Set up the data-collection mode
   a. To select mode, press the up arrow once and press enter.
   b. Select single point from the select mode menu
   c. Select ok to return to the main screen.

8. Collect dissolved oxygen concentration data in single point mode.
   a. Rinse the tip of the probe with a sample of water.
   b. Place the tip of the probe into the stream at site 1, or into a cup with the sample water in it. Submerge the probe tip to a depth of 4-6 cm. Gently stir the probe in the water sample. Keep stirring until you have collected you DO value.
   c. When the readings stabilize to the nearest 0.1mg/L select start to begin sampling. Continue stirring. The reading will appear on your calculator after 10 seconds.
   d. Record this value on your data sheet rounding to the nearest 0.1 mg/L.
   e. Press enter to return to the main screen.
   f. Repeat steps 8 a-e to test a second site.

Table 1: Table showing 100% Dissolved Oxygen Capacity (Mg/L).

	770 mm	760 mm	750 mm	740 mm	730 mm	720 mm	710 mm	700 mm	690 mm	680 mm	670 mm	660 mm
0°C	14.76	14.57	14.38	14.19	13.99	13.80	13.61	13.42	13.23	13.04	12.84	12.65
1°C	14.38	14.19	14.00	13.82	13.63	13.44	13.26	13.07	12.88	12.70	12.51	12.32
2°C	14.01	13.82	13.64	13.46	13.28	13.10	12.92	12.73	12.55	12.37	12.19	12.01
3°C	13.65	13.47	13.29	13.12	12.94	12.76	12.59	12.41	12.23	12.05	11.88	11.70
4°C	13.31	13.13	12.96	12.79	12.61	12.44	12.27	12.10	11.92	11.75	11.58	11.40
5°C	12.97	12.81	12.64	12.47	12.30	12.13	11.96	11.80	11.63	11.46	11.29	11.12
6°C	12.66	12.49	12.33	12.16	12.00	11.83	11.67	11.51	11.34	11.18	11.01	10.85
7°C	12.35	12.19	12.03	11.87	11.71	11.55	11.39	11.23	11.07	10.91	10.75	10.59
8°C	12.05	11.90	11.74	11.58	11.43	11.27	11.11	10.96	10.80	10.65	10.49	10.33
9°C	11.77	11.62	11.46	11.31	11.16	11.01	10.85	10.70	10.55	10.39	10.24	10.09
10°C	11.50	11.35	11.20	11.05	10.90	10.75	10.60	10.45	10.30	10.15	10.00	9.86
11°C	11.24	11.09	10.94	10.80	10.65	10.51	10.36	10.21	10.07	9.92	9.78	9.63
12°C	10.98	10.84	10.70	10.56	10.41	10.27	10.13	9.99	9.84	9.70	9.56	9.41
13°C	10.74	10.60	10.46	10.32	10.18	10.04	9.90	9.77	9.63	9.49	9.35	9.21
14°C	10.51	10.37	10.24	10.10	9.96	9.83	9.69	9.55	9.42	9.28	9.14	9.01
15°C	10.29	10.15	10.02	9.88	9.75	9.62	9.48	9.35	9.22	9.08	8.95	8.82
16°C	10.07	9.94	9.81	9.68	9.55	9.42	9.29	9.15	9.02	8.89	8.76	8.63
17°C	9.86	9.74	9.61	9.48	9.35	9.22	9.10	8.97	8.84	8.71	8.58	8.45
18°C	9.67	9.54	9.41	9.29	9.16	9.04	8.91	8.79	8.66	8.54	8.41	8.28
19°C	9.47	9.35	9.23	9.11	8.98	8.86	8.74	8.61	8.49	8.37	8.24	8.12
20°C	9.29	9.17	9.05	8.93	8.81	8.69	8.57	8.45	8.33	8.20	8.08	7.96
21°C	9.11	9.00	8.88	8.76	8.64	8.52	8.40	8.28	8.17	8.05	7.93	7.81
22°C	8.94	8.83	8.71	8.59	8.48	8.36	8.25	8.13	8.01	7.90	7.78	7.67
23°C	8.78	8.66	8.55	8.44	8.32	8.21	8.09	7.98	7.87	7.75	7.64	7.52
24°C	8.62	8.51	8.40	8.28	8.17	8.06	7.95	7.84	7.72	7.61	7.50	7.39
25°C	8.47	8.36	8.25	8.14	8.03	7.92	7.81	7.70	7.59	7.48	7.37	7.26
26°C	8.32	8.21	8.10	7.99	7.89	7.78	7.67	7.56	7.45	7.35	7.24	7.13
27°C	8.17	8.07	7.96	7.86	7.75	7.64	7.54	7.43	7.33	7.22	7.11	7.01
28°C	8.04	7.93	7.83	7.72	7.62	7.51	7.41	7.30	7.20	7.10	6.99	6.89
29°C	7.90	7.80	7.69	7.59	7.49	7.39	7.28	7.18	7.08	6.98	6.87	6.77
30°C	7.77	7.67	7.57	7.47	7.36	7.26	7.16	7.06	6.96	6.86	6.76	6.66
31°C	7.64	7.54	7.44	7.34	7.24	7.14	7.04	6.94	6.85	6.75	6.65	6.55

TEST #4: Dissolved Oxygen

DATA COLLECTION SHEET

STREAM NAME____________________ DATE___________________________

SITE NUMBER_____________________
TIME____________________________

RESEARCHER NAME______________________________________

Problem:

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Hypothesis:

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Site 1 data table

Column	A	B	C	D	E
Read-ing	Dissolv-ed Oxygen (mg/L)	Water temp (°C)	Atmospheric pressure (mmHg)	100% dissolved oxygen (mg/L)	Percent satura-tion (%)
Example	8.2 mg/L	18.4 °C	760 mmHg	9.5mg/L	86%
1					
2					

Average %	

Site 2 data table

Column	A	B	C	D	E
Read-ing	Dissolv-ed Oxygen (mg/L)	Water temp (°C)	Atmospheric pressure (mmHg)	100% dissolved oxygen (mg/L)	Percent satura-tion (%)
Example	8.2 mg/L	18.4 °C	760 mmHg	9.5mg/L	86%

1					
2					

Average %	

Calculations

A. Record the dissolved oxygen reading from sensor
B. Record the water temperature from the temperature probe (test 1)
C. Record the atmospheric pressure from a barometer.
D. From Table 3, record the 100% dissolved oxygen value using measured temperature and atmospheric pressure.
E. Percent saturation = A / D X 100

OBSERVATIONS FROM FIELD (VEGETATION ALONG STREAM, WEATHER, AND GEOGRAPHY.____

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Conclusion Questions:

Directions: Answer the following questions as completely as possible. Additional information may be needed from the library or the Internet.

1. Would you expect there to be a difference between the dissolved oxygen levels between the two sites? Why?

2. Now that you have the data, what does this test mean?

3. Did you accept or reject your hypothesis? Why?

Student Lab#5: Nitrate

Taken from Water Quality with Calculators by Vernier

Objectives

- To teach students the affect of Nitrates in an aquatic environment.
- To teach students where Nitrates come from.
- To teach students how to take nitrate readings using a CBL2 and Vernier probe.

Overview

In this test we will be measuring the concentration of nitrate ions, NO_3^-, in a water sample. The concentration of nitrate is expressed using the unit mg/L NO_3^-, meaning nitrogen that is in the form of nitrate.

Table 1: Sources of Nitrate Ions

There are many different sources of nitrate. See table 1 for a listing of sources for Nitrate Ions. The nitrate ions found in freshwater samples result from a variety of natural and manmade Table 1: sources. Plants and animals use nitrates as a source of nitrogen to synthesize amino acids and proteins. The majority of nitrogen is found in the atmosphere in the form of nitrogen gas. The nitrogen cycle converts the nitrogen gas into forms that are useable by plants and animals.

• Agriculture runoff • Urban runoff • Animal feedlots and barnyards • Municipal and industrial wastewater • Automobile and industrial emissions • Decomposition of plants and animals

Freshwater usually has a nitrate level of less than 1 mg/L, human sources of nitrate can elevate these levels to above 3 mg/L. Levels above 10mg/L in drinking water can cause a potentially fatal disease in infants called methemoglobinemia or blue baby syndrome. In this disease nitrate converts hemoglobin into a form that can no longer transport oxygen.

Elevated nitrate concentrations can also contribute to a condition in lakes and ponds called eutrophication (the excessive growth of aquatic plants and algae). Eventually, dead plants, leaves, and etc. accumulate on the bottom of the lake, where it decays and makes the problem worse by recycling nutrients. Algal blooms can occur which can be lethal to the organisms in the lake.

The nitrate pollution of groundwater and surface water has become a major ecological problem in many agricultural areas. It was once thought that fertilizer caused most of the pollution, but new evidence is pointing the finger at the concentration of livestock in feedlots.

Expected Levels

Freshwater normally has levels in the range of 0.1 to 4 mg/L NO_3^-. Unpolluted waters usually have nitrate levels below 1 mg/L. See table 2 for nitrate concentration from selected sites around the U.S.

Table 1: Nitrate Concentration in Selected Sites in the U.S. Taken from Water Quality with Calculators by Vernier.

Site	Nitrate Spring Level (mg/L NO_3^-)	Nitrate Fall Level (mg/L NO_3^-)
Mississippi River, Clinton, IA	0.55	1.20
Mississippi River, Memphis, TN	1.60	2.90
Rio Grande River, El Paso, TX	0.38	0.59
Ohio River, Benwood, WV	0.87	1.30
Willamette River, Portland, OR	0.28	0.98

Missouri River, Garrison Dam, ND	0.40	0.14
Hudson River, Poughkeepsie, NY	0.49	0.64
Platte River, Sharpes Station, MO	1.90	1.30

Summary of Methods

We will be using a Vernier Nitrate Ion-Selective Electrode to measure the nitrate-ion concentration above and below the water treatment plant.

Materials Checklist

CBL2 interface
TI-83+ calculator
DataMate program
Nitrate Ion-Selective Electrode
Low Standard (1 mg/L NO_3^- N)
High Standard (100 mg/L NO_3^- N)
Distilled water

Collection and Storage of Samples

1. This test can be conducted on site or in the lab. A 100 mL water sample is required.
2. The water sample must be collected from below the water surface and as far away from shore as possible.
3. If the testing cannot be conducted within a few hours, store samples in an ice chest or refrigerator.

Testing Procedure

1. The Vernier Nitrate Ion-Selective Electrode must be soaked in the High Standard solution for approximately 30 minutes prior to use. It is important that the electrode is not resting on the bottom of the container, and that the small white reference contacts are immersed. Make sure no air bubbles are trapped below the electrode.

2. Plug the Ion Selective Electrode (ISE) into channel 1 of the CBL2 interface. Use the link cable to connect the TI-83+ calculator to the interface. Firmly press in the cable ends.
3. Turn on the calculator and start the DATAMATE program. Press clear to reset the program.
4. Set up the calculator and interface for the ISE.
    a. Select setup from the main screen.
    b. If the calculator displays NO3 ISE (MG/L) in CH. 1, proceed directly to step 5. If it does not, continue with this step to set up your sensor manually.
    c. Press enter to select CH. 1
    d. Select Ion selective from the select sensor menu.
    e. Select NO3 ISE (MG/L) from the ion selective menu.

5. Set up the calibration for the Nitrate ISE
    a. Select calibrate, and then calibrate now.
    b. When the voltage reading is stable press enter
    c. Enter 100 as the concentration of the standard in mg/L NO_3^- N
    d. Rinse the ISE thoroughly with distilled water and gently blot it dry with a tissue or paper towel.
    e. Place the tip of the ISE into the Low standard (1 mg/L NO_3^- N). Be sure that the ISE is immersed and no air bubbles are trapped.
    f. After briefly swirling the solution, hold the ISE still and wait approximately 30 seconds for the voltage reading to stabilize. Press enter.
    g. Enter "1" as the concentration of the standard in mg/L NO_3^- N.
    h. Select OK to return to the setup screen.

6. Set up the data-collection mode.
    a. Rinse the ISE with distilled water and gently blot it dry with a tissue. Place the tip of the ISE into the stream at site 1, or into a cup containing the sample water. Make sure the small white reference contacts are immersed, and that the ISE is not resting on the bottom of the cup. Make sure there are no air bubbles trapped.
    b. After briefly swirling the solution, hold the ISE still and wait approximately 30 seconds for it to stabilize.
    c. Select start to begin sampling. Hold ISE still for next 10 seconds.

d. After 10 seconds the nitrate concentration will appear on the screen. Record this value on your data sheet rounding the value to the nearest 0.01 mg/L NO_3^- N.
e. Press enter to return to the main screen
f. Select start to obtain a second reading.
g. Press enter to return to the main screen

TEST #5 Nitrate Ion-Selective Electrode

DATA COLLECTION SHEET

STREAM NAME__________________ DATE__________________________

SITE NUMBER___________________ TIME__________________________

RESEARCHER NAME_______________________________________

Problem:

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Hypothesis:

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Reading	Site 1 Nitrate (mg/L $NO3^-$-N)	Site 2 Nitrate (mg/L $NO3^-$-N)
1		
2		
Average		
t-test		

OBSERVATIONS FROM FIELD (VEGETATION ALONG STREAM, WEATHER,
AND
GEOGRAPHY.____

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Conclusion Questions

Directions: Answer the following questions as completely as possible. Additional information from the library or Internet may be needed.

1. Did you reject or accept your hypothesis? Why?

2. Now that you have the data, what do they mean?

3. What was the purpose of performing a t-test on this data?

Student Lab #6: Total Dissolved Solid

Taken from Water Quality with Calculators by Vernier

Objectives

- To teach students how dissolved solids affect the environment.
- To teach students how to take total dissolved solid readings using a CBL2 and Vernier probe.

Overview

There are two forms of solids found in streams, suspended and dissolved. Suspended solids include silt, stirred-up bottom sediment, decaying plant matter, or sewage-treatment effluent. Suspended solids will not pass through a filter, whereas dissolved solids have the ability to pass through filters. Dissolved solids in freshwater samples include soluble salts that yield ions such as sodium, calcium, magnesium, bicarbonate, sulfate, or chloride. Total dissolved solids can be determined by evaporating a pre-filtered sample to dryness, and then finding the mass of the dry residue per liter of sample. A second method allows us to use a Vernier probe to conduct an electrical current. The conductivity is then converted to total dissolved

Table 1: Sources of Total Dissolved Solids
• Hard water ions -Ca^{2+} -Mg^{2+} -HCO_3^- • Fertilizer in Agricultural Runoff -NH_4^+ -NO_3^- -PO_4^{3-} -SO_4^{2-} • Urban Runoff -Na^+ -Cl^- • Salinity from tidal mixing, minerals, or returned irrigation water -Na^+ -K^+ -Cl^- • Acidic Rainfall -H^+ -NO_3^- -SO_3^{2-}, SO_4^{2-}

solids.

The total dissolved solid (TDS) concentration in a body of water is affected by many different factors. A high concentration of dissolved ions is not an indication that a stream is polluted or unhealthy. It is normal for streams to dissolve and accumulate fairly high concentrations of ions from the minerals in the rocks and soils over which they flow. If these deposits contain salts (sodium chloride or potassium chloride) or limestone (calcium carbonate), then significant concentrations of Na^+, K^+, CL^- will result as well as hard-water ions, such as CA^{2+} and HCO_3^- from limestone.

Total dissolved solids are sometimes used as a watchdog environmental test. Any change in the ionic composition between testing sites in a steam can quickly be detected by using a conductivity probe. There are many manmade sources of ions that may contribute to elevated TDS readings (see table 1). Fertilizers from fields and lawns can add a variety of ions to a stream. Increases in TDS can also result from runoff from roads that have been salted in the winter. Organic matter from wastewater treatment plants may contribute higher levels of nitrate or phosphate ions. Treated wastewater may also have higher TDS readings than surrounding streams if urban drinking water has been highly chlorinated. Irrigation water that is returned to a stream will often have higher concentrations of sodium or chloride ions. Acidic rainwater, with dissolved gases like CO_2, NO_2, or SO_2, often yields elevated H^+ ion concentrations.

Many forms of aquatic life are affected by high levels of TDS, especially high levels due to dissolved salts. The salts act to dehydrate the skin of animals. The high levels of TDS can also affect the pH levels. If high readings are due to hard-water ions, then soaps may be less effective, or significant boiler plating may occur in heating pipes.

Expected Levels

TDS values inlakes and streams are typically found to be in the range of 50 to 250mg/L. In areas of especially hard water or high salinity, TDS values may be as high as 500mg/L. Drinking water tends to be 25 to 500mg/L TDS. United States Drinking Water Standards include a recommendation that TDS in drinking water should not exceed

500mg/L TDS. Fresh distilled water, by comparison, will usually have a conductivity of 0.5 to 1.5mg/L TDS.

Table 2: TDS in Selected Rivers in the United States

Site	Season	TDS (mg/L)	Season	TDS (mg/L)
Rio Grande River, El Paso TX	Spring	510	Fall	610
Mississippi River, Memphis TN	Spring	133	Fall	220
Sacramento River, Keswick, CA	Spring	71	Fall	60
Ohio River, Benwood, WV	Spring	300	Fall	143
Hudson River, Poughkeepsie, NY	Spring	90	Fall	119

Summary of Methods

A Vernier Conductivity Probe will be used to make our measurements.

Materials Checklist

CBL2 Interface
TI-83+ Graphing Calculator
DataMate program
Vernier Conductivity Probe
Distilled water
500 mg/L TDS standard solution
50 mg/L TDS standard solution

Collection and Storage of Samples

1. This test can be conducted on site or in the lab. A 100 mL water sample is required.
2. It is important to obtain the water sample from below the surface of the water as far away from shore.

3. If the testing cannot be conducted within a few hours, the sample must be refrigerated or placed on ice.

Testing Procedure

1. Set the switch on the Conductivity Probe box to 0-2000μS, which equals 1000mg/L TDS.
2. Plug the conductivity probe into channel 1 of the CBL2 interface. Use the link cable to connect the TI-83+ graphing calculator to the interface. Firmly press in the cable ends.
3. Turn on the calculator and start the datamate program. Press clear to reset the program.
4. Set up the calculator and interface for the conductivity probe.
   a. Select setup from the main menu
   b. Press enter to select CH. 1
   c. Select conductivity from the select sensor menu
   d. Select conduct 1000 (MG/L) from the conductivity menu.
5. Prepare the conductivity probe for calibration
   a. Select calibrate, and then calibrate now.
   b. Perform the first calibration point with the probe in the air
   c. Wait for the readings to stabilize and press enter.
   d. Enter "0" as the mg/L TDS
   e. Place the conductivity probe into the 500 mg/L TDS standard solution. The hole near the tip of the probe should be covered completely.
   f. Wait for the readings to stabilize and press enter
   g. Enter "500" as the mg/L TDS
   h. Select OK to return to the setup screen

6. Setup the data collection mode
   a. To select mode press the up arrow once and press enter.
   b. Select single point from the select mode menu
   c. Select OK to return to the main screen.

7. Collect TDS concentration data
   a. Place the tip of the electrode into a cup with sample water from the body of water you are testing. The hole near the tip of the probe should be covered completely.

b. When the reading has stabilized, select start to begin sampling. Leave the probe tip in the water for the 10 seconds it is sampling.
c. After 10 seconds the TDS value will appear on the calculator screen. Record this value on the Data sheet rounding to the nearest 1mg/L TDS.
d. Press enter to return to the main screen
e. Select start to repeat the measurement. Record this value on the data sheet again rounding to the nearest 1 mg/L TDS
f. Press enter to return to the main screen.

TEST #6: TOTAL DISSOLVED SOLIDS

DATA COLLECTION SHEET

STREAM NAME____________________ DATE___________________________

SITE NUMBER_____________________
TIME____________________________

RESEARCHER NAME____

Problem:
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____
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Hypothesis:
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____
____

Reading	Site 1 TDS (mg/L)	Site 2 TDS (mg/L)
1		
2		
Average		
t-test		

OBSERVATIONS FROM FIELD (VEGETATION ALONG STREAM, WEATHER, AND
GEOGRAPHY.____
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See back page for conclusion questions.

Conclusion Questions

Directions: Answer the following questions as completely as possible. Additional information may be needed from the library or Internet.

1. Did you accept or reject your hypothesis? Why?

2. Now that you have the data, what do they mean?

3. Would you have expected there to be a difference in total dissolved solids between the two sites? Why?

4. What was the reason for performing a t-test with these data?

Student Lab: #7 Total Solids

Taken from Water Quality with Calculators by Vernier

Objectives

- To teach students how to measure the total solids in an aquatic environment.
- To teach students the sources of total solids in an aquatic environment.

Overview

Total solids (TS) is a measure of all the suspended, colloidal, and dissolved solids in a sample of water. This includes dissolved salts, such as sodium chloride, NaCl, and solid particles such as silt and plankton. Having to many solids in a river is a common problem. The Environmental Protection Agency's National Water Quality Inventory has concluded that siltation is the most common pollutant of streams and rivers they sampled.

Many factors can contribute to the total solids in water (table 1). Soil erosion is a large contributor. An increase in water flow or a decrease in stream-bank vegetation can speed up the process of soil erosion and contribute to the levels of suspended particles such a as clay and silt.

Bottom dwelling organisms such as catfish, can contribute to the total solids in the water by stirring up the sediment that has built up on the bottom of the stream. Organic matter such as plankton or decaying plant and animal matter that are suspended in the water will also add to the total solids in a stream.
If the levels of total solids are too high or too low, it can impact the health of the stream and the organisms that live there. High levels of total solids will reduce the clarity of the water. This decreases the amount of sunlight able to penetrate the water, which decreases the photosynthetic rate. The increase in total solids make the stream or lake look aesthetically non-pleasing. With the increased number of total solids the body of water will

heat up faster and higher. The solids will absorb the sunlight causing the increase in temperature. The increase in temperature will lead to many problems of its own.

Expected Levels

Total solids usually fall within the range of 20 mg/L to 500 mg/L. Values can go much high especially after heavy rain when the water levels are high.

Table 1: Sources of Total Solids
• Soil Erosion - silt - clay - dissolved minerals • Agricultural runoff - fertilizers - pesticides - soil erosion • Urban runoff - Road grime - Rooftops - Parking lots • Industrial waste - dissolved salts - sewage treatment effluent - particulates • Organics - microorganisms - decaying plants and animals - gasoline or oil from roads • Abundant bottom dwellers

Site	Season	Total Solids (mg/L)	Season	Total Solids (mg/L)
Hudson River, Poughkeepsie, NY	Spring	134	Fall	259
Colorado River, CO-UT State Line	Spring	1226	Fall	873
Sacramento River, Keswick, CA	Spring	112	Fall	68
Mississippi River, Memphis , TN	Spring	222	Fall	371
Columbia River, Northport, WA	Spring	81	Fall	88

Summary of Methods

We will be determining the total solids in a sample of water by adding a precise amount of water to a carefully cleaned, dried, and weighed beaker. The water is then evaporated away using a drying oven and the beaker is reweighed. The difference in mass before and after is the mass of the total solids.

Materials Checklist

Sampling bottles
100 mL graduated cylinders
Two 250 mL beakers
Drying oven
Balance
Tongs or gloves to hold beaker

Collection and storage of samples

1. This test must be conducted in the lab. Collect 500 mL of sample water so that you can run two 200 mL trials
2. If is important to obtain the water sample from below the surface of the water and as far away from the shore as possible.
3. Stand upstream from any activity that could stir up sediment and affect your readings. Hold the sample body upstream from your body.
4. Store the sample in the refrigerator or on ice.

Testing Procedure

Day 1

1. Prepare two 250 mL beakers for drying and sample evaporation
    a. Carefully clean the two 250 mL beakers and place them in a drying oven at 100-105°C for at least one hour to dry.
    b. Using tongs or gloves remove the beakers form the oven and allow them to cool. From this point on always handle the beakers with gloves to prevent the oils on your hands from affecting the masses of the beakers.
    c. Using a pencil, number your beakers 1 and 2. Do not use labeling tape.
    d. Use a balance to measure the mass of each beaker. Record the values on the data sheet (round to the nearest 0.001g).
    e. Store the beakers in a clean, dry dust-free space until you return to the lab.
2. Transfer the samples to the beakers
    a. Remove any large particles, such as twigs or insect from the sample water.
    b. Swirl the samples to attain uniformity of suspended particles
    c. Using a 100 mL graduated cylinder carefully measure 200mL of sample water into each beaker.

3. Using tongs or gloves place the beakers into the oven and allow the water to evaporate overnight at a temperature of around 100-105°C.

Day 2

4. Measure the mass of the beakers and solids
    a. Using tongs or gloves remove the beakers from the oven and place them in a dessicator if available,

to cool. A dessicator will keep the samples from absorbing any water from the air that would increase their mass.

b. Use a balance to measure the mass of each beaker with the solids now left behind. Record the value on the data sheet (round to the nearest 0.001g).

c. Obtain the mass of the solids by subtracting the mass of the empty beaker from the mass of the beaker with the solids. If the mass of the solids is at least 0.025g, proceed to Step 6. If the mass of the solids is less than 0.025g, proceed to Step 5.

5. If the mass of the solids is less than 0.025g, add another 200 mL of sample to each beaker and repeat steps 3 and 4. Make a note on the data sheet that your total volume is now 400 mL instead of 200 mL.
6. Record the mass of the solids on the Data sheet (round to the nearest 0.001g).

TEST #7: Total Solids

DATA COLLECTION SHEET

STREAM NAME__________________ DATE________________________

SITE NUMBER___________________

TIME_________________________

RESEARCHER NAME___________________________________

Problem:

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____

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Hypothesis:

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SITE 1

Column	A	B	C	D	E	F
Beaker Number	Mass of Empty Beaker (g)	Mass of beaker plus solids (g)	Mass of solids (g)	Mass of solids (mg)	Total Volume (L)	Total solids (mg/L)
Example	95.225g	95.297g	0.042g	42mg	0.200 L	210 mg/L
1						
2						
Average TS (mg/L)						

SITE 2

Column	A	B	C	D	E	F
Beaker Number	Mass of Empty Beaker (g)	Mass of beaker plus solids (g)	Mass of solids (g)	Mass of solids (mg)	Total Volume (L)	Total solids (mg/L)
Example	95.225g	95.297g	0.042g	42mg	0.200L	210 mg/L
1						
2						
Average TS (mg/L)						

Column Procedure

A. Mass of empty beaker
B. Mass of beaker with dried solids
C. Mass of Solids (g) = B-A
D. Mass of solids (mg) = C x 1000
E. Total Volume (L) = mL water/1000
F. Total solids = D/E

OBSERVATIONS FROM FIELD (VEGETATION ALONG STREAM, WEATHER, AND GEOGRAPHY. ______________________________
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Conclusion Questions

Directions: Complete the following questions as completely as possible. Additional information may be needed from the library or Internet.

1. Would you have expected to see a difference in total solids between the two sites? Why?

2. Did you accept or reject your hypothesis? Why?

3. Now that you have the data, what do they mean?

4. What was the purpose of performing a t-test on these data?

Student Lab#8: Fecal Coliform

Overview

The collection of coliform colonies will lead to determining the likelihood of contamination by micro-organisms. Fecal coliform are not disease causing organisms themselves, but they are found next to disease causing organisms. Fecal coliform is often found along with disease causing organisms such as those causing dysentery, gastroenteritis, and hepatitis A. The source of fecal coliform is often raw sewage. The bacteria for fecal coliform are found naturally occurring in the digestive tract of warm-blooded animals. These bacteria are responsible for digestion of food in those animals.

Expected Levels

Table 1: Table showing the desired levels and permissible levels of fecal coliform in water. Units are measured in Colony forming units per 100 milliliters (CFU/100mL).

Water Use	Desired Level (CFU/100mL)	Permissible Level (CFU/100mL)
Drinking	0	0
Swimming	Less than 200	Less than 1000
Boating or fishing	Less than 1000	Less than 5000

Summary of Methods

This test uses nutrient agar plates to grow the fecal coliform colonies. Water is collected from two different sites on the stream. The water sample is put through a serial dilution and streaked on a nutrient agar plate. The plates will be left at room temperature for 48-72 hours after which the colonies will be counted.

List of Materials

Nutrient Agar

3g Yeast extract
5g Peptone
15g Agar
1L Hot distilled water

Hot plate
Autoclave/pressure cooker
Small beakers
Glass innoculum "L"
Bunsen burner
Test Tubes
Disposable Petri Dishes
Erlenmeyer Flask
Pipettes
Testing Procedure

Nutrient Agar

1. Start heating up 1L of distilled water on hot plate, preferably one with the ability to stir.
2. Measure out 3g of yeast extract, 5g of peptone, and 15g of agar.
3. When distilled water is hot add dry ingredients to water and stir until dissolved.

Autoclave

1. The nutrient agar, 100mL of distilled water, and pipettes need to be autoclaved or pressure cooked to be sure they are sterile.
2. Cover water, and agar with tin foil. Wrap pipettes with tin foil.
3. Autoclave them for 15-20 minutes at 15-20 psi. If pressure-cooking, time should be doubled if psi is only 10.
4. When sterilization is complete let agar cool until it can be touched by human hand (approximately 55°).

Pouring the agar

1. The table you will be using to plate the petri dishes needs to be sterilized with bleach. Dump a fair amount on to the table and wipe with a sponge.
2. Lay out your petri dishes, leaving them covered.
3. When the agar is cool enough to poor, fill each petri dish 1/3 to ½ full off agar.
4. Let the agar sit for 20-30 minutes while it sets up.

Serial Dilution

1. You need to complete a series of 4 dilutions. You want to end up with concentrations of 100%, 50%, 25%, 12.5%, 6.25% of river water.
2. Take 4mL of river water out of test tube A and pipette it into another test tube (B), and add 4 mL of autoclaved water to that test tube.
3. Then out of the test tube you just added water to, take out 4mL of water and add to new test tube (C), then add 4mL of autoclaved water to test tube C.
4. After mixing pipette 4mL of water out of test tube C and place into a new test tube (D). Add 4mL of autoclaved water to test tube D as well.
5. After mixing test tube D, pipette 4mL of water out of test tube D and place in new test tube (E), add 4mL of autoclaved water to test tube E.

Plating

1. Pipette 0.1mL out test tube A onto the surface of the first petri dish. Repeat using test tubes B-E all on new petri dishes.
2. Take glass "L" and rinse in ethyl alcohol and flame.
3. After cooling use the glass "L" to spread the water onto the petri dish.
4. Repeat this for all samples.
5. Label each petri dish with concentration, substance inoculated with, and date.
6. Turn these petri dishes upside down and leave at room temperature for 48-72 hours.

Counting Colonies

1. Count the number of colonies for each plate and record them on the data sheet.

TEST #8: Fecal Coliform

DATA COLLECTION SHEET

STREAM NAME____________________ DATE___________________________

SITE NUMBER_____________________

TIME____________________________

RESEARCHER NAME_______________________________________

Directions: Record the number of colonies in the appropriate column on the table below.

Site #	100%	50%	25%	12.5%	6.25%
#1					
#2					
Difference = Site #1 - #2					

Field Observations

____

____

____

____

____

____

______

Student Lab #9: Stream Flow/Volume

Taken from Water Quality with Calculators by Vernier

Objective

- To teach students how to take stream flow readings using a CBL2 and Vernier probe.
- To teach students factors that affect the stream flow.

Overview

Stream flow or discharge is the volume of water that moves through a specific point in a stream during a given period of time. Discharge is usually measured in units of cubic feet per second (cfs). Discharge is measured by measuring a cross sectional area of the stream. The velocity of the stream is measured using a flow rate sensor. The volume can then be calculated by multiplying the cross-sectional area by the flow velocity.

Stream flow is important to the stream ecosystem in many different ways. First of all it is responsible for many of the physical characteristics of a stream. Secondly, it can also modify the chemical and biological aspects of a stream. Aquatic organisms depend on the flow of the stream to bring food and nutrients, and to remove wastes.

There are two important factors to consider when looking at stream discharge. The first factor being the flow velocity, and the second factor being the volume of water in the stream.

Flow velocity is influenced by a few different factors (see table 1). If the surrounding terrain is steep the snow and rain runoff have less time to soak into the ground and therefore the runoff will be greater. Compare that to a farmland where the land is relatively flat, the runoff has a longer period to soak into the ground, leaving very little water left for runoff into streams. The flow velocity also changes with the depth and width of a stream. A good analogy of this is squeezing a hose. When you squeeze a hose the velocity increases. The volume remained constant but the area to flow through has decreased. The same thing happens in a stream when the depth and width of a stream changes.

Table 1: Factors Influencing Flow Velocity

- Depth of stream channel
- Width of stream channel
- Roughness of stream bottom
- Slope or incline of surrounding terrain

The volume of water in the stream is affected by various factors as well (see table 2). Areas with more snow or rainfall will have more water draining into surrounding streams and rivers. Just like there will be different amounts of water in streams during different seasons. Humans have also affected the volume of water in streams. We remove water for drinking, industry, and irrigation. We have also created roads, and parking lots, which prevent water from soaking into the ground.

Table 2: Factors Influencing Stream Volume

- Weather or climate
- Seasonal changes
- Merging tributaries
- Human impact

Expected Levels

The U.S. Geological Service has a website where much of this data is available.
http://water.usgs.gov/realtime.html

Table 3 show stream flow rates for various locations in the United States.

Location	Min (cfs)	Mean (cfs)	Max (cfs)
Mississippi River at Thebes, IL	85,500	310,000	725,000
Missouri River at Hermann, MO	28,500	107,000	382,000
Colorado River at Cisco, UT	2,800	18,000	46,900

Hood River at Hood River, OR	593	1,300	3,160

Summary of Methods

The cross-sectional area will be determined for a stream site using a tape measure and meter stick. Measurements will be made at equal intervals across the stream cross-section. Flow velocity will be measured using the Vernier Flow Rate Sensor at each of the intervals along the cross section. Using these measurements, the stream flow will be calculated.

Materials Checklist

CBL2 interface
TI-83+ Graphing calculator
DataMate Program
Vernier Flow Rate sensor
Measuring Tape (15m - 50ft)
Meter Stick

Testing Procedure

1. Using the measuring tape, determine the width of the stream cross-section in meters and record that measurement on your data collection sheet (round to the nearest 0.01 meters). Divide the cross section into six equally spaced sections.
2. Using the meter stick measure the depth of the stream in meters at each of the equally spaced points along the cross section. Record the depth and the distance out from one shore edge, in meters, on the data collection sheet. It is important to always measure from the same shore. It is also important to include both the initial distance and depth, and the final distance and depth (they should be 0).
3. Plug the flow rate sensor into Channel 1 of the CBL2 interface. Use the link cable to connect the TI-83 Calculator to the CBL2 interface. Firmly press in the cable ends.
4. Turn on the calculator and start the datamate program. Press clear to reset the program.
5. Set up the calculator and interface for the Flow Rate Sensor
    a. Select setup from the main screen

b. If the calculator displays Flow rate (m/s) in CH. 1, proceed to step 6. If it does not, continue with this step to set up your sensor manually.
c. Press enter to select ch. 1
d. Select FLOW RATE (m/s) from the select sensor menu.

6. Set up the data-collection mode
   a. To select mode, press the up arrow and press enter.
   b. Select single point from the select mode menu
   c. Select ok to return to the main screen

7. Collect flow rate data
   a. Place the flow rate sensor at the same points the depth measurements were made in step 2. Since points 1 and 7 are on the shore edge where there is no flow, skip these points and perform flow measurements at the remaining five points.
   b. Submerge the impeller of the flow rate sensor to about 40% of the depth measured at each section. If the section is shallow enough, use the plastic risers that are included with the sensor to support the sensor on the stream bottom. The risers make it easier to keep the impeller of the sensor in the same spot and oriented in the same direction.
   c. Point the impeller of the sensor upstream and directly into the flow. Select start to begin sampling. Hold the sensor in place for 10 seconds while data are being collected. Once data collection is finished, the flow rate will be displayed on the calculator screen. Record the reading on the data sheet.
   d. Press enter to return to the main screen. Move the flow rate sensor to the next section of the stream.
8. Repeat step seven for each of the remaining sections.
9. Repeat steps 1-8 for the cross section at site 2. When the flow velocity at all five sections has been measured exit the datamate program by selecting quit. Important: do not disconnect flow rate sensor from the interface when finished. The sensor must stay connected to complete the stream flow calculation.

10. Use the following procedure to enter the data in your calculator:

a. To view the data lists, press 2nd stat, then select edit.
b. Clear any previous data from lists L1 and L2 by moving the cursor to the L1 heading and press clear, then enter. Do the same for L2
c. Enter the distance measurements from the data sheet in L1.
d. Enter the depth measurements in L2
e. After typing the last value press 2nd quit.

11. To calculate the cross-sectional area of site 1:
a. Start the datamate program
b. Select analyze from the main screen
c. Select integral from the analyze options menu
d. Select CH 1 FLOW RT (ms) from the select graph menu
e. The cursor will be flashing on the first data point. Press enter to select the left boundary.
f. Move the cursor to the last data point and press enter to select the right boundary
g. The INTEGRAL, which represents the cross-sectional area of the stream in meters squared, will be displayed. Record this on your data sheet.
h. Press enter to return to the analyze options screen
i. Repeat steps 10-11 for site 2.

TEST #9: FLOW RATE/VOLUME

DATA COLLECTION SHEET

STREAM NAME____________________ DATE___________________________

SITE NUMBER_____________________

TIME____________________________

RESEARCHER NAME_______________________________________

		SITE 1							SITE 2						
A	WIDTH (M)														
B	DISTANCE (M)	1	2	3	4	5	6	7	1	2	3	4	5	6	7
		0							0						
C	DEPTH (M)	0						0	0						0
D	CROSS-SECTIONAL AREA (M^2)														
E	FLOW VELOCITY (M/S)	1	2	3	4	5	6	7	1	2	3	4	5	6	7
		-						-	-						-
F	AVERAGE VELOCITY (M/S)														
G	STREAM FLOW (M^3/S)														
H	STREAM FLOW (FT^3/S)														

Row Procedure:

a. Record width of stream using a measuring tape
b. Record the distances out from the shore line
c. Record depth of stream using meter stick
d. Record calculated cross-sectional area from step 11
e. Record the flow velocity of each column measured with Flow Rate Sensor

f. Average velocity = SUM E /5
g. Stream flow = D x F
h. Cubic feet per second = G x 35.32
** See back of sheet for observation and conclusions.

OBSERVATIONS FROM FIELD (VEGETATION ALONG STREAM, WEATHER, AND
GEOGRAPHY. ____

CONCLUSIONS FROM RESULTS AND OBSERVATIONS.

Student Lab #10: Macro-invertebrates

Objective

- To teach students the diversity of invertebrates in the streams and the roll they play.
- To determine water quality based on the numbers of invertebrates.

Overview

The relationship between the composition of the aquatic community and water quality has long been recognized. Two methods that are common for evaluating water quality by looking at macro-invertebrates are indicator organisms and diversity indices.

The concept of indicator organisms is based on the fact that every species has a certain range of physical and chemical conditions in which it can survive. Some organisms can survive in a wide range of conditions and are more tolerant of pollution. Others are very sensitive to changes in conditions and are intolerant of pollution. Some examples of pollution sensitive organisms are mayflies, stoneflies, some caddisflies, riffle beetles, and hellgrammites. Examples of pollution tolerant organisms are sludge worms, leeches, and certain midge larva.

The evaluation of water quality is linked to the numbers of pollution tolerant organisms at the site compared with intolerant organisms. A large number of tolerant organisms and few or no intolerant organisms would indicate pollution. Remember that pollution tolerant organisms can be found in both polluted and unpolluted waters.

Diversity refers to the number of different kinds of organisms found in a biological community. Greater diversity means more different types of organisms. In general, communities with high diversity tend to be more stable than those with less diversity.

Pollution tends to reduce the number of species in a community by eliminating organisms that are sensitive to changes in water quality. The total number of organisms may not change, however, if pollution-tolerant organisms increase in abundance.

Summary of Methods

We will be making leaf packs to put in the stream for two weeks. We will then bring them back to the classroom and classify the invertebrates.

Materials Checklist

Bricks
Leaves
Fishing line
Scissors
Large tubs
Preservative jars
Alcohol preservative

Testing Procedure

Making leaf packs

1. You will be making one leaf pack per group.
2. Place brick on side and tie a piece of fishing line (2 meters long) to one end.
3. Start placing 5-7 layers of leafs on the side of the brick
4. Wrap the fishing line around the brick and tie off at the end.
5. Trim the fishing line ends off.

Placing the leaf packs

1. Place the leaf packs in a ripple of the stream with the leafs facing up stream.
2. Move the bricks back and forth to get them to settle into the substrate.

Collecting the leaf packs

1. After two weeks we will come back and collect the leaf packs.
2. Pick up your leaf pack and place in a tub with a little bit of water.

Classifying the organisms

1. Use the flashcards in the room to classify your organisms

2. Mark on a separate sheet of paper a tally of each organism.
3. Fill out student data sheet to determine water quality rating.

TEST #10: Macro-Invertebrates

DATA COLLECTION SHEET

STREAM NAME__________________ DATE__________________

SITE NUMBER____________________ TIME__________________

RESEARCHER NAME_____________________________________

Problem:

____

____

____

Hypothesis:

____

____

____

OBSERVATIONS FROM FIELD (VEGETATION ALONG STREAM, WEATHER, AND
GEOGRAPHY.____

____

____

____

____

Directions: Fill in the chart on the back of this page by classifying the invertebrates you collected from the stream. Use the following letter coding system to fill in your chart.

A = 1-9
B = 10-99
C = > 100

Stream Quality Assessment Chart

Group 1	Letter	Group 2	Letter	Group 3	Letter	Group 4	Letter
Stone-fly		Caddis-fly		Black fly		Worms	
Alder-fly		Mayfly		Midge		Leech	
Dobson-fly		Riffle Beetle		Sow bug		Left Snail	
Snipe fly		Water Penny		Scud		Blood-worm midge	
		Damsel-fly		Right Snail			
		Dragon-fly					
		Crayfish					
		Crane fly					
		Clam / mussle					

A.# taxa = _______ # taxa = _______ #taxa = _______ #taxa = _____

B. x 1 = _______ x 2 = _________ x 3 = ________ x 4 = ________

Calculations

Total of all group scores (Sum line B) _______
Divided by
Total # of different taxa (Sum line A) _______

Total Cumulative Score = _______________

1 - 2.0	Excellent water Quality
2.1 - 2.5	Good Water Quality
2.6 - 3.5	Fair Water Quality
Over 3.5	Poor Water Quality

APPENDIX C

Homework Assignments

Temperature Homework Name: ____________________

1. Explain thermal pollution and its effect on the stream. Use an example in your answer.

2. Explain how runoff can raise the temperature of a stream.

3. Why is temperature an important aspect of water quality?

4. In terms of temperature only, where would you choose to go trout fishing, south east Michigan or Northern Michigan? Explain.

5. Design a lab that would test the theory that colder waters dissolve more gas. Be very specific.

PH Homework   Name: ______________________

1. Explain the idea of pH. What makes up pH? What is the formula for pH? What is the pH scale and how does it work?

2. Why is pH an important indication of water quality?

3. What do heavy metals do to fish?

4. What are some processes that can change the pH value of streams?

5. Explain what it means when the pH of a stream rises from a pH of 8 to a pH of 9.

Nitrogen Homework   Name: ____________________

1. Why is nitrogen important to animals and plants?

2. What can elevated levels of nitrate concentrations lead to in lakes and ponds?

3. Where does the majority of nitrate pollution come from?

4. Why is an elevated level of nitrate bad for drinking water?

5. Would you expect a higher level of nitrates in the spring or in the fall? Why?

Fecal Coliform Homework Name: ___________________

1. Why is water tested for fecal coliform rather than for pathogenic bacteria?

2. How do fecal coliforms get into the water?

3. List the fecal coliform standards for drinking water and for swimming water.

4. What characteristics of fecal coliform bacteria make them useful as indicator organisms?

5. Why should you collect samples for fecal coliform testing in sterile bottles?

6. Why must the water samples be refrigerated if testing for fecal coliform cannot be done immediately? How soon after collection must samples be tested?

7. Explain how the fecal coliform level at Bean Creek might affect the organisms living in or near the waterway.

8. Predict how fecal coliform levels might vary at Bean Creek at different times of the year. Explain your reasoning.

9. What would you recommend to improve the fecal coliform levels and water quality at your site? Support your opinion.

10. Students analyzed several samples of water and found the following data:

Sample Site Number	Type of Water	Fecal Coliforms per 100 mL
1	Well water	4 colonies
2	Lake water	2800 colonies
3	River water	1250 colonies
4	City water	3 colonies
5	Lake water	120 colonies
6	River water	800 colonies

a. Based on the preceding test results, which sites have water that would be safe to drink? Explain.

b. What might have caused the fecal coliform levels at each site?

c. What should be done with the two drinking-water supplies they sampled?

Dissolved Oxygen Homework Name: ________________

1. In your own words, what is dissolved oxygen, and why is it important in aquatic habitats?

2. How does the solubility of gases in liquids change with shifts in temperature?

3. John and Angie went fishing one hot summer day. Angie let her fishing line hang several meters deeper in the river than John. She caught her limit of fish, while he caught only one catfish. Offer a hypothesis as to why Angie caught more fish than John. How would you test to prove that hypothesis?

4. Explain how the amount of dissolved oxygen in the water at Bean Creek might affect the organisms living in the waterway.

5. Predict how the concentration of dissolved oxygen in the water at Bean Creek might vary at different times of the year. Explain your reasoning.

6. What might be done to improve the level of dissolved oxygen in the water at Bean Creek?

Guidelines for River Poster Board

Objectives:

- Students will be able to access reliable Internet sites to locate information on streams.
- Students will be able to describe different chemical tests performed on streams.
- Students will be able to discuss the results of different tests performed on streams.

Directions:

- Pick a stream or river you would like to study. It may be easier to pick a larger river that is well known so that data can be found.
- You need to find Internet sites that post water quality data on a particular river or stream.
- Write down the data of the tests that we have been studying in class for that river.
- Complete a water quality index sheet on the river to decide what the water quality is.
- Design a poster board explaining what you found using pictures, charts, words, and explanations.
- When designing your poster board you should take into consideration, color, size, layout, neatness, and organization.
- Everything on your poster board should be typed, and then pasted if need be.
- A hint for you is to look on the government websites of states. You may also want to look at the DNR websites.
- You will be required to give a 5-minute presentation covering your poster board.
    - You may wish to include the location of your river.
    - What kind of land surrounds the river?
    - What is the river used for?
    - Has it had a history of being polluted?
    - What are people doing to regulate this river?
    - As well as what the results to the water quality tests were, and what do they mean.
- You need to include a works cited page on the back of your poster. A listing of all websites that you took information from must be included for any credit.

River of Your Dreams: A Collage

To be accompanied with the water quality unit for Biology 1 at Addison High School. Taken from Rivers Curriculum Guide.

Introduction

Have you ever heard the expression that a picture speaks a thousand words? In this assignment you are going to get that chance. When you are trying to explain something or feelings to someone, often a picture works better than words. A collection of pictures may even be more effective than one picture. A collage is a collection of pictures and other materials, selected and arranged to present a message to the viewer. Over the course of this water quality unit you will construct a collage whose message relates to a river's water quality, the organisms living in or along its banks, and the uses of rivers and streams by humans.

In the early stages of your collage, you will need to decide what message you want to convey to others. Your message should involve each of the lessons you will study in the water quality unit, but it should not just be a unit summary or jumble of water and river pictures. In considering what message you want to communicate, you may want to consider the quality of the river site you are depicting. What living things can be found along or in that river? How are humans affecting the site either positively or negatively? What things are taking place at the site? What parameters affect the site the most? Do you hike or picnic along its shore? Is it used for your drinking water? Does treated sewage water end up there? What industries rely on the river?

Decide what you want others to be aware of. You may want to consider the beauty of the river or stream; its value as habitat; its value to humans as a water supply, a source of transportation; its power and destructiveness in a flood; or the effects of such human actions as removal of vegetation from stream banks, construction of dams, drainage of wetlands, dredging, pollution, or overuse by industries or municipalities. Will it be a good river, a bad river, a river of the future, or a river of the past?

PROCEDURE

1. Decide on a general topic or theme. Write out the message you want to convey. List kinds of pictures you could use to convey that message. Decide if you will need to include other materials or verbal messages. Make sketches of possible arrangements.
2. After completing each lesson, add to your collage. Determine a message from that lesson that adds to the central theme. Your message should weave through the different lessons. As you select and gather materials, you may find pictures in magazines or at various water-related Internet sites. Drawings, even cartoons, might help. Each time you consider materials for you collage, ask yourself, How will this express my message? If you have no answer, look for different materials instead.
3. Collect your collage materials in a large envelope labeled with your name and class. Keep the envelope in the file cabinet with the rest of the classes. Do not attach materials to your board until you have covered several lessons. Especially, wait until you have made a trip or two to your Local River or stream.
4. Experiment with the sizes, shapes, and colors you have collected. Anticipate what you might want to add after upcoming lessons. The arrangement should be visually pleasing, with thought given to color, form, shape, and line. Balancing pictures, print, and white space contributes to the effectiveness of a collage.
5. When you are satisfied with your arrangement, attach the materials to the poster board. Include a title in the collage that represents your theme. The title can be included in the collage or added to the display as one would in an art gallery.
6. When your collage is completed, tape a sheet of paper on the back with your name, class, and date. Also write a paragraph that abstracts or summarizes your collage. Include responses to the instructions that follow.
   a. Provide your name, and your theme or topic.
   b. Describe the message you wished to convey
   c. Describe how you have used pictures to convey that message
   d. Add any other information that will help the reader make more sense of the collage and better understand its message.

PERFORMANCE CRITERIA

You have artistic freedom in your use of pictures, printed materials, and other items for your collage. Your grade will be based on whether you have followed the procedures described in this sheet. The successful collage will:

- Feature a single message or theme throughout the collage. The message is evident through pictures and organization and may also be stated in print.
- Contain materials representing each Water Quality Unit lesson studied.
- Clearly demonstrate organization and planning. The collage is neatly constructed.
- Reflect artistic considerations, such as use of color, space, balance, and line
- Have an accompanying sheet containing complete responses to the instructions listed in step 6 of the student handout. Responses show insights into the use of a collage to present a message.
- Be complemented by an oral presentation that emphasizes the message and the relationship of the different parts of the collage to the message.

APPENDIX D

Scoring Rubrics

Scoring Rubric for Biological Field Proficiency Checklist

SCORE	EXPECTATIONS
1	Achieved only a few proficiencies, or many were not completed to required level.
2	Attempted each item, but most work reflects poor performance or inadequate attention to the activity and its completion
3	Achieved proficiency on each item, and work reflects average performance. Work demonstrates a limited understanding of laboratory procedures and concepts. Written conclusions are logical but weak or incomplete.
4	Achieved proficiency on each item, and work reflects excellent performance in all areas evaluated. Student has followed laboratory procedures and attempted to analyze data and draw conclusions. Observations and conclusions are logical, often including additional observations and measurements. Students helps others meet proficiency
5	Achieved proficiency on each item, and work reflects top student performance in all areas evaluated. Student understood lab procedures and used that to analyze data and draw conclusions. Work frequently includes additional observations, readings, and resources. Student helps others meet proficiency

Scoring Rubric for River of Your Dreams Collage

SCORE	EXPECTATIONS
0	No collage is completed
1	A collage was started but is incomplete or shows no theme or message.
2	A collage is completed and a theme or message used. Only a few of the lessons are represented by the collage. Questions are completed.
3	A collage is completed and a theme or message used. Materials from most lessons were included and supported the theme. The summary report was completed and an understanding of the themes and ideas presented in the collage was shown.
4	A collage is completed that conveys a theme or message using ideas from all the lessons. The display is neatly constructed and shows good use of space. Responses written in the summary or report show an understanding of the use of collages to relay a message.

Scoring Rubric for River Research Poster Board.

SCORE	EXPECTATIONS
0	No poster board is completed
1	A poster board was started but is incomplete.
2	A poster board is completed. Only a few of the water quality tests are represented by the poster board.
3	A poster board is completed. Materials from most water quality tests were included. The summary report was completed and an understanding of the themes and ideas presented in the poster board was shown.
4	A poster board is completed that conveys a theme or message using ideas from all the water quality tests. The display is neatly constructed and shows good use of space. Responses in the summary or report show an understanding of the use of poster board to relay a message.

APPENDIX E

Quizzes

PH and Temperature Quiz Name: ____________________

Make the following conversions

1. 45°F = ____________°C

2. 38.6°C = ___________°F

3. What were the two buffers used to calibrate the pH probe?

4. If you had to calibrate the temperature probe, how would you do it?

5. What are two factors that affect temperature in streams?

6. What are two factors that affect pH in streams?

7. What does the CBL2 do with the data it collects for 10 seconds?

8. Was there a difference in temperature between the two streams? If so why would there be a difference?

9. How is the water supposed to be collected for the pH and temperature test?

10. Draw and explain the pH scale.

Nitrate and Total Dissolved Solid Name: ______________

1. List two sources of Nitrate ions.

2. The concentration of nitrate ions is expressed in what units?

3. What was the nitrate level of Bean Creek?

4. What are the two forms of solids found in streams?

5. What probe was used to measure the total dissolved solid?

6. Explain how you calibrated the probe for total dissolved solid.

7. List two sources of total dissolved solids.

8. Are nitrate levels usually higher in the spring or in the fall? Why?

Macro-Invertebrates Quiz Name: ____________________

______1. Alderfly

______2. Dobsonfly

______3. Caddisfly

______4. Mayfly

______5. Stonefly

______6. Crane fly

______7. Black Fly Larvae

______8. Midge

______9. Blood Worm Midge

______10. Crayfish

______11. Sow bugs

______12. Leech

______13. Damselfly

______14. Dragonfly

______15. Water Penny

______16. Planarians

______17. Water Striders

______18. Riffle Beetle

______19. Scud

A. Simulidae

B. Trichoptera

C. Nematocera

D. Zygoptera

E. Hirudinea

F. Ephemeroptera

G. Coleoptera

H. Amphipoda

I. Plecoptera

J. Sialidae

K. Corydalidae

L. Psephenidae

M. Odonata

N. Platyhlminthes

O. Isopoda

P. Decapoda

Q. Chironomidae

R. Gerridae

Fecal Coliform and Total Solids Name:____________________

1. List two sources of Fecal Coliform.

2. List two sources of Total Solids.

3. Is the amount of total solids higher in the spring or in the fall? Why?

4. Explain the process of measuring total solids. Be specific.

5. List the desired levels of fecal coliform in drinking water, swimming water, and boating or fishing water.

6. How many coliforms were found in Bean Creek? (/100mL).

Chloride and Dissolved Oxygen Nam

Date: ______________________

1. Did Bean Creek have a high, low or average chloride level?

2. Did Bean Creek have a high, low or average D.O level?

3. What did you have to pipette into the tip of the D.O probe?

4. Draw a line graph showing the relationship between D.O and Temperature.

5. List two sources of Chloride ions in a stream.

6. List the major source of dissolved oxygen in a stream.

7. Explain how you calibrated the D.O probe. Be specific.

8. Why did you need to take a barometer reading before you performed your D.O test?

APPENDIX F

Attitude Survey

Directions: Answer the following survey as truthfully as possible. There are no right or wrong answers and you will not be graded on this. I am looking for the overall attitude of biology students to science.

Biology

1. Strange	1	2	3	4	5	Familiar
2. Good	1	2	3	4	5	Bad
3. Dull	1	2	3	4	5	Fun
4. Interesting	1	2	3	4	5	Boring
5. Easy	1	2	3	4	5	Difficult
6. Unimportant	1	2	3	4	5	Important
7. Career	1	2	3	4	5	Hobby

Laboratory Activities

8. Strange	1	2	3	4	5	Familiar
9. Good	1	2	3	4	5	Bad
10.Dull	1	2	3	4	5	Fun
11.Interesting	1	2	3	4	5	Boring
12.Easy	1	2	3	4	5	Difficult
13.Unimportant	1	2	3	4	5	Important
14.Dangerous	1	2	3	4	5	Safe

Working in Teams to Solve Problems in Class

15.Strange	1	2	3	4	5	Familiar
16.Good	1	2	3	4	5	Bad
17.Dull	1	2	3	4	5	Fun
18.Difficult	1	2	3	4	5	Easy
19.Busy	1	2	3	4	5	Quiet
20.Unimportant	1	2	3	4	5	Important
21.Useful	1	2	3	4	5	Wastefull

Scientific Method

22.Strange	1	2	3	4	5	Familiar
23.Good	1	2	3	4	5	Bad
24.Dull	1	2	3	4	5	Fun
25.Interesting	1	2	3	4	5	Boring
26.Easy	1	2	3	4	5	Difficult
27.Unimportant	1	2	3	4	5	Important
28.Useful	1	2	3	4	5	Unnecessary

Water Testing

29.Strange	1	2	3	4	5	Familiar
30.Good	1	2	3	4	5	Bad
31.Important	1	2	3	4	5	Unimportant
32.Interesting	1	2	3	4	5	Boring
33.Easy	1	2	3	4	5	Difficult

34.Necessary	1	2	3	4	5	Unnecessary
Recycling						
35.Strange	1	2	3	4	5	Familiar
36.Good	1	2	3	4	5	Bad
37.Dull	1	2	3	4	5	Fun
38.Interesting	1	2	3	4	5	Boring
39.Easy	1	2	3	4	5	Difficult
40.Unimportant	1	2	3	4	5	Important
Local Rivers						
41.Polluted	1	2	3	4	5	Clean
42.Beautiful	1	2	3	4	5	Ugly
43.Important	1	2	3	4	5	Unimportant
44.Drinkable	1	2	3	4	5	Undrinkable
45.Uninhabited	1	2	3	4	5	Inhabited
Cell Biology						
46.Important	1	2	3	4	5	Unimportant
47.Interesting	1	2	3	4	5	Boring
48.Easy	1	2	3	4	5	Difficult
49.Dull	1	2	3	4	5	Fun
50.Strange	1	2	3	4	5	Familiar
Ecology						
51.Important	1	2	3	4	5	Unimportant
52.Interesting	1	2	3	4	5	Boring
53.Easy	1	2	3	4	5	Difficult
54.Dull	1	2	3	4	5	Fun
55.Strange	1	2	3	4	5	Familiar
DNA/Genetics						
56.Important	1	2	3	4	5	Unimportant
57.Interesting	1	2	3	4	5	Boring
58.Easy	1	2	3	4	5	Difficult
59.Dull	1	2	3	4	5	Fun
60.Strange	1	2	3	4	5	Familiar

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