

ATLAS Project Sample
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Summary:

As part of the ATLAS program, I have been collaborating with my colleague Mark Reinhold, Professor of Science at Northern Essex Community College. We have been working on creating college-compatible adaptations for Engineering is Elementary (EIE) lessons that we can incorporate into Science courses for pre-service teachers in Massachusetts Community and State Colleges. EIE units consist of an initial lesson involving a storybook that illustrates an engineering design problem, a second lesson that deals with the roles of engineers in solving problems, a third lesson that allows students to collect data revealing some of the scientific knowledge necessary for the engineering problem at hand, and a final lesson in which students use the engineering design process to solve a problem. We've tried to explore ways to model these components of the EIE curriculum in a college-level science class. Our goal is not necessarily to expose pre-service teachers to identical activities to those they would conduct with students (although sometimes this is appropriate), but to make it clear that science and technology/engineering instruction can be integrated, and to introduce some of the same science concepts and engineering processes that are found in related EIE units.

Example: Infusing Engineering and Technology in a Biology Course

One example of an EIE unit that covers topics that would also be covered in a College course on Life Science is the unit on membranes, accompanied by the storybook, *Juan Daniel's Fútbol Frog*. For teachers to effectively use this unit it helps if they have both an understanding of the biology of frogs and the functioning of biological membranes. It is invaluable to illustrate for pre-service teachers that science content like this can be taught in the context of identifying and solving problems in the world around us. In order to accomplish this, utilizing technology developed through the engineering design process, collecting scientific data to better understand the problem and potential solutions, and using the engineering design process to solve a problem are important steps.

I suggest a combination of activities that are unique to the content being covered and activities that can cut across multiple content areas over the duration of a course. For instance, you can structure a specific lab activity to illustrate how technology can be applied to solving a particular problem and allow students to collect data. On the other hand, you can also have class-wide projects that run throughout the course. You might ask students to help their classmates place science content in a broader societal context, and also to utilize the engineering design process to create a product that will help people outside of the classroom. In the case of my honors course, Leadership in Biological Issues and Inquiry, these two projects consist of each student helping to lead a bioethics discussion, and each students designing and completing a service learning project.

The bioethics discussion assignment should help students to learn to place the content we are covering in a broader context. For instance, just as the story, *Juan Daniel's Fútbol*

Frog can be used at the start of an EIE unit to introduce an engineering problem, I plan on having all students in the class read National Geographic's April 2009 article, The Vanishing (<http://ngm.nationalgeographic.com/2009/04/amphibian/holland-text>). This will be done the same week we will be discussing biological membranes. Two students will be responsible that week for completing their Bioethics Discussion Assignment by summarizing the content and ethical issues related to the reading and leading their classmates in a discussion of this reading. The lists below compare the objectives of an elementary school class reading *Juan Daniel's Fútbol Frog* with a College class reading *The Vanishing*. I have also included my rubric for the Bioethics Assignment.

Bioethics Discussion Assignment

Rubric

Standard	Does not meet Standard: 1	Partially meets Standard: 2	Meets or exceeds Standard: 3	Rank
Background information	Student fails to provide most of the relevant Biological background necessary or incorporates glaring factual errors while speaking in front of the class.	Student summarizes the Biological background necessary with minor factual errors or omissions of relevant information while speaking in front of the class with visual aids.	Student accurately summarizes the relevant Biological background information necessary to address the issue by speaking in front of the class and using visual aids in PowerPoint.	
Ethical issues	Student does not adequately address most of the important ethical issues that must be considered or treats them all in a biased fashion while speaking in front of the class.	Student addresses some of the important ethical issues that must be considered, but omits some or treats them unequally in a biased manner while speaking in front of the class.	Student addresses the important ethical issues that must be considered when dealing with this topic in an even-handed manner while speaking in front of the class using visual aids.	
Discussion questions	Student does not present at least 2 major questions for discussion related to the topic and the questions fail to draw on either the students' knowledge of biology or their ethical priorities.	Student presents in front of the class at least 2 major questions for discussion related to the topic that either ask students to draw on their knowledge of biology or their ethical priorities, but together do not integrate these aspects of the topic.	Student presents in front of the class at least 3 major questions for discussion related to the topic that together ask students to draw on both their knowledge of the biology involved in the topic and their own ethical priorities.	
Leading Discussion	Student does not facilitate discussion by calling on classmates or responding to their opinions resulting in little student participation.	Student facilitates the discussion by calling on classmates and responding to their opinions, but fails to remain even-handed or to encourage contributions from all students.	Student facilitates the discussion by calling on classmates, responding to their opinions in an even-handed manner, and encouraging contributions from all of the students.	
Communication	Student does not express themselves clearly in speaking and in their visual aids, incorporating a number of errors in terminology, lack of definitions, or major grammatical and spelling errors.	Student expresses themselves clearly in speaking and in their visual aids with only a few errors in terminology, lack of definitions, or minor grammatical and spelling errors.	Student expresses themselves clearly in speaking and in their visual aids by using appropriate terminology, defining that terminology and making no major grammatical or spelling errors.	

Elementary Level Objectives	College Level Objectives
<ul style="list-style-type: none"> Recognize the roles of bioengineers in designing technologies. 	<ul style="list-style-type: none"> Propose biological and bioengineering solutions to amphibian decline.
<ul style="list-style-type: none"> Explain that a membrane separates or protects structures. 	<ul style="list-style-type: none"> Explain Chytrid's role in amphibian decline in terms of membranes.
<ul style="list-style-type: none"> Identify the basic needs of organisms and how they are met. 	<ul style="list-style-type: none"> Explain other factors in amphibian decline in terms of their ecology.
<ul style="list-style-type: none"> Discuss how events in the story represent the design process. 	<ul style="list-style-type: none"> Discuss the costs and benefits of different design solutions.

The same week we run the bioethics discussion on frog population decline, we also do a lab on biological membranes and the process of osmosis. Prior to that lab all students are expected to have completed an essay based on the class discussion of the issues surrounding amphibian decline that deals with potential solutions to the biodiversity problem particularly with regard to amphibians. Once again, the objectives of this assignment correspond with the objectives of the EIE unit, in this case lesson 2 of the EIE unit that focuses more closely on how engineers come up with solutions to problems by looking to the natural world. A comparison of the objectives is provided below.

Elementary Level Objectives	College Level Objectives
<ul style="list-style-type: none"> Distinguish between objects found in the natural world and technologies. 	<ul style="list-style-type: none"> Identify biological factors and technological solutions that preserve biodiversity.
<ul style="list-style-type: none"> Match an object found in the natural world to a technology with similar function. 	<ul style="list-style-type: none"> Explain how biological solutions can be adapted to help preserve biodiversity.
<ul style="list-style-type: none"> Recognize that bioengineers look to the natural world to inspire technologies. 	<ul style="list-style-type: none"> Describe the roles biologists, bioengineers, and policy makers can play in preserving biodiversity.

After considering these issues and submitting their essays students then complete the lab for the week. While the lab does not deal directly with amphibian decline, it deals with biological membranes, and can be organized around the essential question: "Why are amphibians particularly susceptible to environmental disturbances of various kinds." The simple answer to this is they rely heavily on their skin in an aquatic environment as a surface for gas exchange, but understanding why they rely on their skin requires an understanding of the process of exchange of materials across membranes and the relationship between diffusion, surface area and volume. The lab has been designed to illustrate these crucial points. A sample lab handout is on the following pages and a comparison of the objectives for the EIE unit and the lab follow the handout.

Name _____ Date _____

Cells and Cell Membranes

The cell is the basic structural and functional unit of living organisms. As we discussed in lecture cell size, structure and membrane properties are all essential for conducting the reactions of life. This lab will afford you with an opportunity to view and measure both plant and animal cells, as well as to observe how the semi-permeable nature of cell membranes interacts with varying environmental concentrations of solute to produce changes at the cellular and organismal levels. Because there are a number of elements to this lab, you will want to read through them all carefully so you can budget your lab time appropriately to complete the entire lab. While it is the last part of the lab handout, you should set up the potato osmosis experiment before you begin observing cells.

Part I: Observing and measuring cells:

A. Cells vary in size. The diameter of prokaryotic cells is as little as 1 to 2 μm (micrometers), while eukaryotic cells range from 5 to 100 μm in diameter. To give you a point of reference for these sizes, the smallest dust speck that you can see is about 100 to 200 μm in diameter. Therefore, when we observe and measure cells we must use the microscope. The measurement units appropriate for cells and cell structures can be described as follows: $10^3 \text{ nm (nanometers)} = 1 \mu\text{m} = 10^{-3} \text{ mm} = 10^{-4} \text{ cm}$.

In order to estimate the size of cells we are viewing through a microscope we must first know the diameter of the field of view. This can be measured in millimeters for a relatively low power magnification (10x objective lens X 10x ocular lens = 100x) by simply placing a ruler in the field of view.

1. Observe a ruler under the microscope on low power. Draw a sketch of what you see on a separate sheet of paper.
2. Determine the diameter of the field of view and list it next to the magnification at the bottom of the picture.

B. From this measurement, the diameter of the field of view at any other magnification can be calculated using the equation:

Current diameter * current magnification = new diameter * new magnification

1. Calculate the diameter of the field of view at each of the other magnifications and list those next to the appropriate magnifications on the same sheet.
2. Finally, move the ruler around in the field of view, and answer the following question.
3. What direction does the image move relative to the actual motion of the ruler?

C. The next step is to use the diameter of the field of view to estimate the size of an actual cell. In order to do this, you must identify a cell under the microscope and estimate the number of cells that can fit across the diameter of the field of view and divide the diameter by that number to get the approximate length, width or diameter of the cell.

1. Scrape the inside of your cheek gently with a toothpick. Place the scrapings in a drop of water on a clean glass slide. Add a cover slip and examine under low power. Once you have located some cells, center them in the field of view and switch to high power. You may need to adjust the light level with the diaphragm to see the cells. You may also want to treat the cells with some methylene blue by placing a drop of it on the edge of the coverslip and placing a piece of absorbent paper (Kimwipe) at the opposite edge. As the paper absorbs the water from under the coverslip, the dye will be pulled under the coverslip to replace the water. This is yet another illustration of the cohesion of water formed by hydrogen bonds. The methylene blue is a dye so please use caution and avoid contact with your eyes, skin or clothes. Refer to the Material Data Safety sheet at the front of the lab and contact me immediately with any questions or problems.
2. Draw a picture of one of the cells on a separate sheet of paper, labeling the nucleus and plasma membrane as well as listing the magnification, approximate cell diameter and radius. From these measurements you can then approximate cell surface area and volume using the equation for a sphere.
3. Surface area of a sphere = $4\pi r^2$
4. Volume of a sphere = $\frac{4}{3}\pi r^3$
5. Calculate the approximate surface area and volume of a cheek cell.
6. Explain why we would classify this cell as a eukaryotic cell.

D. You can make similar observations and calculations for a plant cell. Place an elodea leaf, top side up, on a clean microscope slide in 2-3 drops of pond water. Cover with a cover-slip and look for cells under low magnification. Center the cells in the field of view and switch to higher magnification.

1. Draw a picture of a plant cell, labeling the cell wall, plasma membrane, chloroplasts and if possible, the nucleus (it is sometimes hard to see among the chloroplasts). List the magnification, cell length, and cell width. You should calculate the surface area and volume for the plant cell by assuming it is a rectangular box. Since we can only see the box in two dimensions, we know its length and width but not its height. By assuming the height is equal to the width, you should calculate surface area and volume using the following equations:
2. Surface area of a box = $2 * \text{length} * \text{height} + 2 * \text{length} * \text{width} + 2 * \text{height} * \text{width}$
3. Volume of a box = $\text{length} * \text{width} * \text{height}$
4. List the surface area and volume of the plant cell
5. What are the crucial differences between a plant cell and an animal cell?
6. Why do we classify the plant cell as a eukaryotic cell like the animal cell we observed?

Either keep your slide of the elodea leaf for later use or go on to step IIA at this point.

- E. Observe one of the samples of cyanobacteria under the microscope.
1. Sketch the organism on a separate sheet of paper, labeling any structures of the cell that you can recognize.

2. List the magnification, cell size, surface area and volume below the picture.
3. Are these organisms prokaryotic or eukaryotic, why?
4. How do most eukaryotic and prokaryotic cells differ in surface area to volume ratio?

Part II Diffusion and Osmosis

A. Lift up the cover slip on your elodea leaf. Remove the water and replace it with .6M sucrose, then put the cover slip back on the plant tissue. Make a labeled drawing of what you see on a separate sheet of paper.

B. Lift up the cover slip again, remove the .6M sucrose by soaking it up with the edge of a Kimwipe and replace it with distilled water.

1. Make another labeled drawing on a separate sheet of paper.
2. Once you have observed the cells carefully in each condition answer the following questions:
 - How did the cell change in .6M sucrose and in distilled water?
 - How do you explain this change in cellular appearance?

You can imagine that this change at the cellular level can also have an effect at the level of a whole organism. In the final section of this lab, we will be looking at the effect of different concentrations on a section of potato. In class we discussed how materials move from high concentration to low concentration by diffusion and we said that this principle applies to water even though we don't usually talk about the "concentration" of water. For the purposes of this lab we will use the terms, high "water potential" to mean a high "concentration" of water or in other words a low concentration of solutes or in other words a low osmolarity. Conversely a low "water potential" occurs when there is a high concentration of dissolved solutes in the water, a high osmolarity.

To get a better understanding of how water moves across a semipermeable membrane you should use the spreadsheet provided to first calculate osmolarity of different solutions on the first page of the spreadsheet, and second to calculate how that will effect the volume of a cell.

1. Based on the way we calculate osmolarity on the first page of the spreadsheet, what are the osmolarities of the different sucrose solutions we are using?
2. Based on the way we calculate volume change in the second page of the spreadsheet which of these solutions would draw the most water across a semipermeable membrane creating the greatest increase in volume on the side of the solution?
3. In the spreadsheet we manipulate the concentration of solute on one side of a semipremeable membrane that has pure water on the other side. However, in the lab, we will have potato cells on the other side of the membrane. Would you suspect potatoes have a higher or lower osmolarity than pure water?
4. Under what conditions will water move out of the potato and into the solution side of the membrane like in our spreadsheet simulation and in what conditions will it move into the potato and out of solution?

We will be manipulating the concentration of the solute sucrose in water and observing how it influences the movement of water into our out of the cells of a potato. Follow the instructions provided and answer the last questions at the end of the lab:

1. Based on what you know about the process of osmosis, explain what you predict will happen in each of the treatments and why you made that prediction.
2. Describe the pattern of change in the volume of the potato samples and accompany this description with a graph.
3. Describe the pattern of change in the mass of the potato samples and accompany this description with a graph.
4. Explain the patterns of change in the mass of the potato samples in terms of the treatments into which they were placed and the movement of water via osmosis.

Elementary Level Objectives	College Level Objectives
<ul style="list-style-type: none"> • Discuss how some organisms meet their basic needs. 	<ul style="list-style-type: none"> • Discuss how cellular membranes help organisms meet their basic needs.
<ul style="list-style-type: none"> • Observe and describe the properties of a natural membrane. 	<ul style="list-style-type: none"> • Compare and contrast how the membranes in potato cores respond to hyper and hypotonic solutions.
<ul style="list-style-type: none"> • Observe, analyze and compare the performances of model membrane materials. 	

Just as students rotate through the roles of leading bioethics discussions by picking one week's topic for which they will lead the discussion, students also pick one of the week's topics to cover in their final service learning project. As almost all of the students in this pre-service course are teachers the problem they are trying to solve is usually how to teach material related to this topic to appropriate age-level students. However, they need to turn this project around and think of it not just as lesson planning but as engineering design, and often their projects involve designing posters, presentations or other manipulatives that can be used in the classroom again and again. I encourage this process of engineering design by forcing them to think about the engineering design process in the same way that students do in an EIE unit.

I use the same list of 5 elements of engineering design, but they are used in two separate steps. In the first step students prepare an initial proposal in which they "Ask" how they can serve a particular constituency such as a certain grade level of students in a community or even a population of frogs in a pond, using the content that we have covered in the course such as what they learned about cell membranes. Students also "Imagine" what goals they would set for this project, and they "Plan" how they will meet these goals and just as importantly how they will assess their success. After this proposal is prepared, presented and approved they can begin work on their service learning project. Once they have completed the project they must present their work to the whole class. At this point we get to see what they "Create" in the engineering process and how they have used data they collected on their project to evaluate and "Improve" the project. In this way students work through the engineering design process. The steps in the engineering design process as defined in the EIE curriculum are compared below to the

steps my students go through, and the rubrics I use for the service learning project proposal and final presentation are provided on the pages that follow.

Step in the Engineering Process -	What did you do to complete this step?
Ask	
Imagine	
Plan	
Create	
Improve	

- Ask how you can serve a particular constituency using science content knowledge.
- Imagine how you could achieve the goals that you set for yourself.
- Plan the project you will be conducting to meet these goals including a way to assess your own success.
- Create your service learning project.
- Evaluate the data from the project to improve and continue the project.

Service Learning Proposal

Rubric

Standard	Does not meet Standard: 1	Partially meets Standard: 2	Meets or exceeds Standard: 3	Rank
Constituency to be served	Student fails to provide information about the constituency to be served by the project or the needs of this group that can be met by the project.	Student gives a sense of a general constituency that could be served by the project and provides a general sense of the needs of this group that can be served by the project.	Student identifies the specific constituency to be served by the project and provides a detailed description of the needs of this group that can be served by the project.	
Course content applied	Student does not adequately address relevant course content that will be used to develop the project, or does so in a way that demonstrates no understanding.	Student addresses the relevant course content that will be used to develop the project clearly but with some inaccuracies or incompleteness showing partial understanding.	Student addresses the relevant course content that will be used to develop the project clearly, accurately and thoroughly, demonstrating understanding.	
Goals of the project	Student does not identify at least one clear goal and is lacking in any measurable outcomes or links between goals, constituency needs, and proposed application of course content.	Student identifies at least one clear goal, but it lacks a measurable outcome for the project or it is not clearly aligned with the needs of the constituency of the proposed application of course content.	Student identifies a number of clear goals with measurable outcomes for the project, and these goals are aligned with the needs of the constituency and the relevant course content to be applied.	
Assessment Plan	Student does not propose an approach to assessing the project that includes a clear description of how data will be collected or how the data will relate to the goals.	Student proposes an approach to assessing the projects success that either does not include a clear description of how the data will be collected or for which data is not clearly related to the goals	Student proposes a workable approach to assessing the projects success including a description of how the data will be collected and how the data will relate to the goals.	
Communication	Student does not express themselves clearly with introductions, supporting paragraphs, concluding paragraphs and makes grammatical or spelling errors.	Student expresses themselves fairly clearly with introductions, supporting paragraphs, concluding paragraphs, but includes some grammatical or spelling errors.	Student expresses themselves clearly in paragraph form with introductions, supporting paragraphs, concluding paragraphs and no major grammatical or spelling errors.	

Service Learning Presentation

Rubric

Standard	Does not meet Standard: 1	Partially meets Standard: 2	Meets or exceeds Standard: 3	Rank
Constituency to be served	Student fails to provide information about the constituency served by the project or how the needs of this group were met by the project.	Student gives a sense of a general constituency that may have been served by the project and provides a general sense of how the needs of this group may have been served.	Student identifies the specific constituency served by the project and provides a detailed description of how the project met the needs of this group.	
Course content applied	Student does not adequately address relevant course content that was used to develop the project, or does so in a way that demonstrates no understanding.	Student addresses the relevant course content that was used to develop the project clearly but with some inaccuracies or incompleteness showing partial understanding.	Student addresses the relevant course content that was used to develop the project clearly, accurately and thoroughly, demonstrating understanding.	
Goals of the project	Student does not demonstrate that they have met at least one clear goal and is lacking in any measurable outcomes or links between goals, constituency needs and course content.	Student demonstrates they have met at least one clear goal but without carefully documenting a measurable outcome aligned with the needs of the constituency and the application of course content.	Student demonstrates they have met a number of their goals by documenting measurable outcomes aligned with the needs of the constituency and the relevant course content.	
Assessment Plan	Student does not provide an approach to assessing the project that includes a clear description of how data were collected or how the data relate to the goals.	Student provides a means of assessing the project success that either does not include a clear description of how the data was collected or for which data is not clearly related to the goals	Student provides a clear and effective means of assessing the projects success including a description of how the data was collected and how the data relates to the goals.	
Communication	Student does not express themselves clearly in speaking and in the use of props or visual aids, with a number of errors in terminology, lack of definitions or major grammatical and spelling errors.	Student expresses themselves fairly clearly in speaking and in their use of props or visual aids with only a few errors in terminology, lack of definitions, grammar or spelling.	Student expresses themselves clearly in oral form and in the use of props or visual aids by using appropriate terminology, defining that terminology and making no major grammatical or spelling errors.	