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Environmental Teaching Methods
Natural Resources 310

Assignment 2
Writing an Environmental Education Unit Plan
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NRES 310
Assignment 2: Writing an Environmental Education Unit Plan

1. An aspect of environmental education I would like to incorporate into the astronomy class is the issue of light pollution. What is the effect of light pollution on our environment? There are several reasons why I would like to include a study of light pollution in the class.

a. Esthetic- An increasing number of Americans are not able to enjoy the beauty of a dark night sky. A large percentage of the U.S. population cannot see the Milky Way and in many large cities, only a few of the brightest stars can be seen. Poor lighting techniques can cause glare that creates dangerous or unsightly situations.

b. Astronomical/ Scientific- Light from our cities brightens the sky background and makes dim objects in the sky impossible to see. Light pollution is a serious problem that affects the study of astronomical objects. Observatories located near urban centers are being compromised because of the increased light output of the cities as they grow.

c. Energy Waste/ Air and Water Pollution- Light pollution represents a waste of millions of dollars of energy and the production of associated pollution while generating that energy. Wise lighting techniques direct the light where it is needed and reduce the watts required for the task.

2. This topic is being incorporated into the CESA Cluster A, Astronomy Online class. Students from Altoona, Augusta, Fall Creek, and Osseo-Fairchild in grades 10-12 are enrolled. The class meets at Hobbs Observatory in rural Fall Creek for 8 sessions per semester. Extensive use of live internet is used at each session. Weekly assignments are posted online consisting of internet website worksheets and selected textbook questions that are emailed to the instructor. Students complete two individual observing projects per semester using their own observations of the night sky. The topic of light pollution can be incorporated into the internet worksheets, one of the class sessions, and into one of the observing projects.

3. I will describe five activities that will help address the question, “What is the effect of light pollution on our environment?”, beginning on page number 4.

4. The research question outlined in #1 is "What is the effect of light pollution on our environment?" The five activities designed to answer that question are:

- What is light pollution?
- How is the study of astronomy affected by light pollution?
- What types of lighting fixtures are being used in your community?
- How much light pollution is in the sky over your home?
- What is the lighting budget for your nearest city, and how much could be saved?

a. The activities are in this sequence, because the introduction, "What is light pollution?" should precede the other activities. The last three activities are done as individual observing projects during the semester and likely, only one of those projects would be done by an individual student.

b. I expect that these activities will stimulate the students and encourage them to be active in these types of activities for years after they are out of school. These are somewhat unusual projects and the lessons learned would not be forgotten quickly.

c. The five activities cover the EE sub goals, grade level, and Wisconsin EE Standards well. I had some difficulty, though, relating astronomy activities to the standards in category B, knowledge of environmental processes and systems. This category deals extensively with ecosystems and I chose not to introduce biological systems into the study of astronomy.

Some of the grade level standards are targeted for grade 8 and others are for grade 12. I teach students in grades 10-12 in my astronomy class. I think it is appropriate to incorporate both 8^{th} and 12^{th} grade standards in this class. Students have strengths and weaknesses in various areas and I think they benefit from a standard even though they are in a higher grade.

Activity #1.

WHAT IS LIGHT POLLUTION?

1.) Rationale.

The purpose of this activity is to introduce students to the issue of light pollution. Students may be familiar with air and water pollution, but may never have considered how unnecessary night lighting destroys our view of the night sky. There are "good" and "bad" choices in selecting lighting fixtures. Some direct the light to where it is needed and others broadcast light in undesired patterns. There is a wide range in the energy efficiency of light sources. We will start by looking at a satellite photo of the US at night to see that even some of our smallest towns are visible because of light pollution.

2.) Objectives/Intended Learning Outcomes.

The objectives of this lesson are to:

- Define light pollution.
- Sketch and describe an ideal outdoor light fixture.
- Determine if your town is visible from space due to light pollution.
- Discuss one remedy for light pollution.

3.) Materials and References.

- Websites as listed in the procedure.
- Article, J. Andersen, "Astronomy and the Degrading Environment", SCIENCE, Vol. 288, Apr. 21, 2000, p. 443-5

4.) Procedure.

Introduction – the instructor will show the students a satellite photo of the US at night at http://www.darksky.org/images/satelite/usa_lights_small.gif to show the night time view of the country and see how much light is sent upward and wasted. They will be impressed to see how easily even small towns show up on the satellite photo.

Body of Lesson – Ask students to identify the major cities on the photo. Can they point out their home town on the photo?

Show a set of slides taken at night in the nearest large city. Ask students to individually think for a few moments, then have someone explain how the night lighting can be seen by satellites. Why is so much of the light directed upward?

Use http://www.darksky.org/products/slide_setg.html , IDA slide set g, to show light fixture types and the patterns they produce. Show "good" types versus "bad" types. The best lighting directs light to where it is needed with a minimum of glare. "Good" fixtures allow less wattage, higher efficiency bulbs to be used. See "New Jersey Light Pollution Study Commission Recommendations" at http://www.darksky.org/infoshts/is121.html .

If lower wattage bulbs can be used, less electricity is being generated, electric bills are lower, and less pollution is being produced by the power company. Read about light regulations and voluntary action. Discuss the article, "Astronomy and the Degrading Environment" by J. Andersen.

Closure – Students will make a sketch of their design of the "perfect" street light fixture. When all have finished sketching (allow only about 5 minutes maximum), each will briefly present their design to the class and explain why it was designed that way.

5.) Assessment/Evaluation.
Students are orally "quizzed" along the way, and the quizzes are integrated into the body of the lesson. A question from this lesson will appear on the next exam. A couple of sample questions are shown below.

1. An ideal streetlight casts light _____.
    a. uniformly in all directions
    b. strongest in a horizontal direction
    c. downward with little horizontal contribution
    d. horizontally with some upward contribution

2. One of the many benefits of wise outdoor night lighting is _____.
    a. less pollution is emitted from power plants
    b. higher wattage bulbs can be used
    c. cities would be much easier to see from the International Space Station
    d. higher profits for electric utilities

6.) Environmental Education Standards
The following EE standards are covered by this lesson.

A.8.5 Use the results of their investigations to develop answers, draw conclusions, and revise their personal understanding.

A.12.5 Communicate the results of their investigations to groups concerned with the issue.

B.8.15 Analyze how people impact their environment through resource use.

D.12.9 Describe the regulatory and economic approaches to improving the environment and explain the advantages and disadvantages of each.

Activity #2.

HOW IS THE STUDY OF ASTRONOMY AFFECTED BY LIGHT POLLUTION?

1.) Rationale.

The purpose of this study is to see how the study of astronomy is affected by light pollution. In our internet worksheet about telescopes, we will find out what can be done to reduce the problem. When the sky background is bright from light pollution, dim objects are difficult to study.

2.) Objectives/Intended Learning Outcomes.

The objectives of this lesson are to:

- Describe how light pollution has changed at Palomar Observatory during the past 50 years.
- Learn what can be done to reduce light pollution at observatories.

3.) Materials and References.

- Websites as listed in the procedure.
- PHYSICS TODAY, "Light Pollution Out West Concerns Optical Astronomers", December 1984, pages 63-4.
- PHYSICS TODAY, "Light Pollution Out West Concerns Optical Astronomers", December 1984, page 144.

4.) Procedure.

This lesson is introduced as a part of the Internet Worksheet about telescopes. Students will be given the articles from Physics Today for background reading at the previous class session. Students will go to the listed websites and find the correct answer to fill in the blank. The following paragraph is from the worksheet:

Go to http://www.astro.caltech.edu/observatories/palomar/public/movies/pollution.html and in the first paragraph, click on "animation". The growth of (San Diego) (1), Escondido, and other communities have added to the light pollution at (Palomar) (2) Mountain. View the animation to see the increase of light pollution during the past fifty years. Simple precautions that can be taken to reduce light pollution include using the (minimum) (3) amount of outdoor lighting required, (shield) (4) lights to prevent upward illumination and turn lights (off) (5) when not needed.

5.) Assessment/Evaluation.

Worksheets are graded and students receive one point for each correct answer. The next exam will contain one question from material included in this worksheet. A couple of sample questions are shown below.

1. Light pollution at Palomar observatory during the past fifty years _____.
    a. is staying about the same
    b. has increased continually
    c. has decreased continually
    d. increased for a few years, but has now been reduced

2. Precautions that reduce light pollution include _____.
    a. maximizing the amount of outdoor lighting
    b. utilizing upward illumination
    c. turning lights on at dusk and off at dawn
    d. shielding lights to prevent upward illumination

6.) Environmental Education Standards.
The following EE standards are covered by this lesson.

A.8.5 Use the results of their investigations to develop answers, draw conclusions, and revise their personal understanding.

B.8.10 Explain and cite examples of how humans shape the environment.

D.12.4 Describe the rights and responsibilities of citizenship in regard to environmental problems and issues.

Activity #3.

WHAT TYPES OF LIGHTING FIXTURES ARE BEING USED IN YOUR COMMUNITY?

1.) Rationale.

The purpose of this project is to observe what types of outdoor lighting are used in our community and to discover which types are the best choices from a perspective of reducing light pollution. By making sketches and photos of outdoor light fixtures and the patterns of light they make, you will be able to determine what is the most desirable lighting. This project will be done as an individual semester observing project.

2.) Objectives/Intended Learning Outcomes.

The objectives of this lesson are to:

- Survey the types of outdoor lighting in the community.
- Distinguish between "good" and "bad" lighting.
- Learn how to do night photography and sketches of lighting.
- Discuss improvements that could be made in the community lighting.

3.) Materials and References.

- Websites as listed in the procedure.
- Sketchpad
- Camera and tripod

4.) Procedure.

Go to http://www.darksky.org/products/products.html and view two sets of twenty slides each, A1 and A2. The captions on the right side will guide you through each show. After viewing the slide shows online, tour your city at night and make note of the different types of outdoor light fixtures being used.

Find examples of "good" and "bad" lighting. With your sketchpad, make line drawings of at least four different light fixtures and in a separate color, possibly yellow, indicate the patterns and direction that light makes around the fixtures. Write comments about each fixture type, mentioning its usefulness, glare, and whether the light shines where it is needed.

Use an astronomy class camera and tripod to photograph the fixture and it's light pattern. Remember to bracket three exposures, changing the exposure time from thirty seconds, one minute, and two minute exposure times. Include the best exposed photo on your sketch page to show a photographic view of the lighting.

Write about one page to summarize what you observed, answering the following questions. What could be done to make the lighting better? Is your neighborhood wasting lighting? What are good points about the area lighting? What is the single greatest change you would like to make about the lighting? As a good citizen, what are changes you could make on your own home or property to reduce light pollution?

5.) Assessment/Evaluation.
This project will be graded on neatness (20%) and completion of the four objectives (80%). Be sure to cover each of the objectives thoroughly.

6.) Environmental Education Standards.
The following EE standards are covered by this project.

A.8.2 Collect information from a variety of resources, conduct experiments, and develop possible solutions to their investigations.

A.8.5 Use the results of their investigations to develop answers, draw conclusions, and revise their personal understanding.

A.12.4 State and interpret their results accurately and consider other explanations for their results.

D.12.4 Describe the rights and responsibilities of citizenship in regard to environmental problems or issues.

Activity #4.

HOW MUCH LIGHT POLLUTION IS IN THE SKY OVER YOUR HOME?

1.) Rationale.

You can measure the effects of light pollution quantitatively by observing stars of known magnitude. The magnitude of the faintest star that can be seen in the night sky on any given night is known as the limiting magnitude. You can determine your limiting magnitude in a city and compare it with the limiting magnitude several miles away from the city and find the effect of light pollution from the city lighting.

2.) Objectives/Intended Learning Outcomes.

The objectives of this lesson are to:

- Determine the limiting magnitude at your home.
- Determine the limiting magnitude at an alternate site.
- Determine the loss of magnitude due to light pollution.
- Document the source of light pollution at the brightest site.

3.) Materials and References.

- Websites as listed in the procedure.

4.) Procedure.

Light pollution makes it impossible to see faint stars and the worse the pollution is, the fewer stars we can see. To quantitatively measure the effect of light pollution, we need to determine the magnitude of the faintest stars we can see, called the limiting magnitude.

Go to http://www.space.com/spacewatch/little_dipper_020628.html and read the page, "The Little Dipper's Stars Reveal Your Sky's Darkness" by Joe Rao to orient yourself to this constellation.

Go to http://www.heavens-above.com/ , the Heavens-Above main page. Scroll down to "Astronomy", then click on "Constellations". For your study, you will need a constellation that is easily visible at a dark sky site, but marginal the light polluted sky you are comparing. The constellation Ursa Minor (The Little Dipper) contains stars in the magnitude 2-4 range, useful for determining limiting magnitude. Print out the constellation diagram and the chart of "The Brighter Stars". The magnitudes of the stars are listed. As you look at the constellation in the night sky from the first location, find the faintest star you can see and note the magnitude on the chart. Then drive to your other location and find the magnitude of the faintest star you can see.

The magnitude difference between the two sites is due to light pollution. In a one page report, list the stars you used and include the faintest magnitude that was visible at each site. What is the magnitude difference between the two sites? What is the limiting magnitude of the stars at your two sites? How many magnitudes are lost because of light pollution? What is the main source of light pollution at your most polluted site? Please include printouts from Heavens-Above.com in your report.

5.) Assessment/Evaluation.
This project will be done as an individual observing project. The project report is worth 250 points. The point distribution will be 20% for neatness, and 20% for each of the four objectives. Be sure to cover each of the objectives completely.

6.) Environmental Education Standards.
The following EE standards are covered by this project.

A.8.2 Collect information from a variety of resources, conduct experiments, and develop possible solutions to their investigations.

A.8.5 Use the results of their investigations to develop answers, draw conclusions, and revise their personal understanding.

A.12.4 State and interpret their results accurately and consider other explanations for their results.

B.8.18 Identify major air, water, or land pollutants and their sources.

Activity #5.

WHAT IS THE ANNUAL LIGHTING BUDGET FOR YOUR NEAREST CITY AND HOW MUCH COULD BE SAVED?

1.) Rationale.

A percentage of the night lighting used in a city goes straight up to space and is completely wasted. If we can make an estimate of how much light is wasted, and find out what the city's annual lighting budget is, we can calculate how much dollars worth of energy is being wasted per year. An annual budget to improve or replace inefficient lighting equipment can be made to reduce subsequent annual waste.

2.) Objectives/Intended Learning Outcomes.

The objectives of this lesson are to:

- Describe an economic approach to reducing light pollution.
- Find the annual expense your city spends on street lighting.
- Estimate how much energy is wasted in your city per year for lighting.
- Find how much money could be saved by well designed lighting fixtures?

3.) Materials and References.

- Websites as listed in procedure.
- The student will meet with city personnel to acquire data for this study.

4.) Procedure.

Large cities spend great amounts of money for street lighting annually. To prepare yourself for this study, go to http://www.ci.la.ca.us/BSL/bslfact.htm to see the facts and figures about street lighting in Los Angeles, California. They use 230,000 street lights to illuminate 5,500 miles of street at an annual electricity cost of $17 million! You may perform an internet study to get these numbers for other cities. The cities in our area do not use this much energy, but it is still a significant amount. This project involves getting the figures for the annual street lighting energy costs for your nearest city and try to determine what percentage could be saved by shielding or replacing the streetlights with fixtures that do not direct light upwards or where it is not wanted or needed.

Contact your local city government to acquire the annual street lighting dollar amounts. Try to isolate street lighting energy costs (for example, $36,000) from the overall municipal electric bill that will include other electricity consumption by the city. Ask if there are current plans to upgrade lights to newer designs and efficiencies.

Next, observe street lights at night and make notes and sketches as you estimate how much light from street lights is being directed in horizontal and upward directions. This is wasted light and electricity. Note the different styles of street light fixtures and estimate how many of each type the city operates. You will end up with an overall estimate of the fraction of light that is being wasted (for example, 0.3).

Now multiply the fraction of wasted light by the dollar amount you found for the annual street lighting cost. For example, $36,000 times 0.3 equals $10,800. This is the annual amount of money that could be saved if the street lights were properly designed and shielded. In your report, include all of the details about your meeting with city officials, your methods to estimate light loss on street lights, and all of your calculations.

5.) Assessment/Evaluation.
This project will be graded on neatness (20%) and completion of the four objectives (80%). Be sure to cover each of the four objectives completely.

6.) Environmental Education Standards.
The following EE standards are covered by this project.

A.8.2 Collect information from a variety of resources, conduct experiments, and develop possible solutions to their investigations.

A.8.5 Use the results of their investigations to develop answers, draw conclusions, and revise their personal understanding.

A.12.1 Identify questions that require skilled investigation to solve current problems cited in literature, media, or observed through personal observations.

A.12.4 State and interpret their results accurately and consider other explanations for their results.

D.12.2 Evaluate reasons for participation or non-participation in an environmental activity in the home, school, or community.

D.12.9 Describe the regulatory and economic approaches to improving the environment and explain the advantages and disadvantages of each.

E.12.3 Take action in regard to environmental issues in the home, school, or communities.