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# ACHIEVING RELEVANCE IN AN INTRODUCTORY ENVIRONMENTAL SCIENCE COURSE THROUGH PRE-SERVICE TEACHER ARTIFACTS

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**ABSTRACT.** Beginning in the Fall 2002 semester, science departments at Ball State University were required to document content learned by pre-service teachers enrolled in science courses. This documentation was to be achieved by creating new assignments for science courses that matched state standards for teacher licensure. The purpose of this article is to discuss how one department initiated new assignments in an introductory environmental science course that not only served the needs of pre-service teachers but also were relevant to the science majors and non-science majors enrolled in the course. Three examples of assignments are discussed as they relate to finding common ground among students from different majors in an introductory course and for promoting scientific and environmental literacy.

**Keywords:** Pre-service teachers, environmental literacy, science education

In the Fall of 2002, Ball State University began a campus-wide initiative to document the content learned by pre-service teachers in science courses. Science departments across the university were mandated to create artifacts for pre-service teachers. Artifacts were defined as specific class assignments with corresponding grading rubrics that students would keep for future teaching portfolios. In the Department of Natural Resources and Environmental Management (NREM), an introductory environmental science course is taught that is required of the pre-service teachers in the life-science licensure program. These students are seeking a license in life science for teaching senior high school, junior high school, or both. They are required to take only one course from the department, namely NREM 101, "Environment and Society."

Two other sub-populations served by this course are science majors, e.g., in NREM or other programs, and non-science majors fulfilling a requirement in the university core curriculum. It is a challenging course to teach because of the variety of students it attracts and the need to make content relevant to students from different disciplines. This pattern of teaching science majors and non-science majors as well as pre-service teachers in the same course is not unique to NREM 101. Other science courses at Ball State University are also taught in this way, for example, Geography 101, Geology 101, Health Science 160 and others. Therefore, the overall goal in creating new assignments for the introductory environmental science course was to provide content appropriate to all students that also matched state standards for life-science licensure among the pre-service teachers.

The need for documenting science content learned among pre-service teachers had been clearly identified, and the start date had been established by university mandate. In preparation, I was assigned as the representative from the NREM Department to serve on the life-science licensure committee for the university and was responsible for developing the new artifact-assignments for the "Environment and Society" course. My intent was to create assignments that could be used by all faculty members teaching the introductory course. After the assignments were created, they were given to the other four instructors to obtain their feedback. As a group, the faculty members responsible for the course had discussions about how the pre-service teacher artifacts required could ideally benefit all students in the class. Three new assignments were created based on two current debates in the environmental field that all instructors felt were important to cover, namely human population growth and global climate change. These particular topics also match well with pre-service teaching standards of the Indiana

Professional Standards Board (IPSB). The assignments were designed to be either laboratory or take-home assignments for use in the class.

## SUB-POPULATIONS IN THE CLASSROOM

The three sub-populations in the introductory environmental science course are now considered and discussed based on a review of relevant literature.

**Pre-service teachers.**—A literature review shows that other faculty teaching introductory science courses have evaluated course content and considered the needs of pre-service teachers. Starr (1995) explored cooperative learning in a geology course for pre-service elementary-school teachers. Part of her motivation was to find a user-friendly method that encouraged women to enroll and remain in the sciences. She tested cooperative learning to see what results it would have on achievement in the course. Results suggested that interactive, group learning techniques helped students grasp geologic concepts such as minerals and rock formation, plate tectonics, and geologic time. Her students were better able to learn course content when they interacted with each other. The content in Starr's geology course applies to the introductory course "Environment and Society" being discussed in this article, because similar topics are covered.

Heppert et al. (2002) discussed techniques for enhancing introductory chemistry courses for pre-service teachers at the University of Kansas. They suggested problem-based, inquiry learning units and interdisciplinary elements to increase the relevance of the course content for teacher education students.

The introductory environmental science course, NREM 101, is taught by several faculty members in the department and serves a large number of students each semester. Even though only a few students in the class are teacher education majors, faculty have the important task of developing the environmental literacy of these science teachers-in-training. An example of the language that was included in the syllabus for addressing pre-service teachers is as follows:

> *New for Fall 2002:* Teacher education majors are advised to document what they have learned in their classes to show that content acquired matches state standards for the teaching license being sought. If you are a teaching major, or if you think you will ever decide to be teaching major, you should save each assignment (called an artifact) given by your instructor for a teaching portfolio.

The instructors of this course invest in the development of pre-service teachers who will teach many junior high and high school students in the future. Ambers (2002) offered this perspective:

> College represents the last opportunity the educational system has to impress students with the importance of learning science, and it is the training ground of future science teachers.

For these reasons, pre-service teachers are an important sub-population in an introductory science course and their need for meeting state education standards relates to decisions about course content by faculty members.

**Science majors.**—Science majors take the introductory environmental science class as a foundation course for their science programs. They need to establish an understanding of basic scientific principles on which they can build as they continue in their majors and areas of study. Science majors must gain competencies with scientific concepts as they relate to environmental issues, such as the states of matter, the basic process of photosynthesis, population models, etc. Hoots (1999) argued for inquiry-based science for science majors as well as the need for adding a humanistic side to science. By adding a humanistic side to the classroom, science majors can appreciate the contributions of other fields, e.g., creative writing and communication for teaching others, especially the general public, about science.

Examples from the literature discussed thus far have suggested that both pre-service teachers and science majors can benefit from interdisciplinary perspectives applied to environmental issues. They need to understand how non-science disciplines affect environmental decision-making. This is the type of perspective that students who are non-science majors can bring to an introductory science course.

**Non-science majors.**—The needs of non-science majors are particularly deserving of some consideration because, for many, this class serves as one of a relatively small number of science courses they take at the university. Further, non-science majors are the largest sub-population in the introductory environmental science course being discussed. In the Fall 2002 semester, 90% of students enrolled in the "Environment and Society" course were non-science majors. For these students, the primary goals of this course are to promote their understanding of basic science to improve their scientific and environmental literacy and to help them see the relevance of understanding environmental issues in their daily lives. One means of achieving these goals is to show the bridges between science and other fields, such as the arts and humanities. This was the intent of an interdisciplinary course at Northern Arizona University linking art, math, and chemistry, designed specifically for non-science majors (Kelley et al. 2001). As an example of such a link, students considered how scientific methods could relate to proving artwork as authentic or forgery, for example, using chemical analyses. As another example, the Workshop Biology course at the University of Oregon was designed to show the philosophy of *science in context*, meaning . . . the role science plays in society has personal and social implications. These examples suggest that an interdisciplinary approach may prove beneficial for non-science majors.

There are common goals for all students in an introductory environmental science course. Non-science majors as well as science majors and pre-service teachers should all be better able to decipher the current debates that surround environmental issues after they leave an introductory course. They should improve their critical thinking skills as they learn the content. For example, they should be more knowledgeable when reading a newspaper about an environmental issue, such as global climate change or human population growth, and should be able to detect biases on both sides of a particular debate. Regardless of their majors, students in the course should be able to apply basic science to environmental issues. The pre-service teacher artifacts were designed to accomplish these common goals for all three sub-populations in the classroom.

## ESTABLISHING A SENSE OF RELEVANCE

Environmental issues can be taught in such a way that the science behind them is relevant to the general public; for example, environmental quality affects our personal health, the quality of our food and water supplies, and energy for our homes and cars (Udovic et al. 2002). Moseley (2000) argued that environmental literacy requires a progression, or continuum, of learning: nominal literacy is the ability to recognize basic environmental terms; functional environmental literacy is the ability to bring ideas together in forming action positions on environmental issues; and operational environmental literacy allows students to choose a course of action from among alternatives. Students should also develop "the skills needed to make decisions where science, technology, and human values interface" (Berkson & Harrison 2002). This is a progression that needs to develop over time. Students in the first few weeks of an introductory environmental science course are at the early stages of Moseley's continuum, i.e., learning basic environmental concepts. As the semester progresses, they should begin to bring concepts together and have a better understanding of the complexity of environmental issues. Near the end of the course they begin to think about action alternatives in their everyday lives; however, this type of higher level thinking has to come with time throughout their college careers and on into adulthood. Thus the stage of operational environmental literacy, or the end of Moseley's continuum has to develop beyond an introductory course into their adulthood. The early stages of environmental literacy can begin in an introductory course.

Wallace (2002) argued that environmental science should begin as early as possible in a student's college program. He suggested that environmental literacy should be nurtured in the freshman year. In this way, students can have a foundation in environmental concepts with which to balance the conventional wisdom of their disciplines and majors that they pursue in subsequent years. He also implied that students should be taught to consider many different points of view surrounding environmental issues.

Salmon (2000) echoed this suggestion. He argued that environmental issues, by their vary nature, should be open to debate, and that this debate is the kind of material ripe for student contemplation. Environmental education curricula should present environmental issues from many perspectives, i.e., material should be based less on trying to mold behavior solely from one perspective, and more on trying to build knowledge, awareness and critical thinking. He noted the following:

> Giving students oversimplified answers to complex problems does not make them effective citizens and can even breed cynicism . . . Even among environmentalists, there is no consensus on what constitutes 'sound' environmental choices . . . on what are the most effective solutions for many environmental problems, and to state or imply there is constitutes a form of miseducation.

In addition, learning science and the process of scientific inquiry involves more than just memorization of facts. Other perspectives are that science is a way of knowing, i.e., "science as inquiry," or that science has context in our personal and social lives (Udovic et al. 2002). Hoots (1999) suggested that the humanistic side of science should be incorporated into introductory courses. As she aptly described:

> Too often we tend to confuse information with understanding. Knowledge without meaning or understanding is nothing more than empty rhetoric. To accommodate the information, it must be meaningfully woven into stories that can be related to our experiences and that will enable us to expand our perceptions.

The point to be made here is that effective teaching of environmental science incorporates a degree of relevance, i.e., a connection between course content and a student's understanding. Ham (1992) argued that environmental information is relevant when it is meaningful and personal. Being meaningful implies that it has context because the information connects to previously acquired knowledge, while being personal suggests that the information is something students feel is important. Berkson and Harrison (2002) suggested: "achieving scientific literacy requires students to understand how science is applied in the real world." Thus, critical thinking and a sense of relevance was deemed important for all three sub-populations in the environmental science course and guided the introduction of the new artifact-assignments.

**Artifacts as assignments for all students.**—In creating pre-service teacher artifacts that would serve as assignments for all students, I chose two broad topics that are currently debated in the environmental field. I was responsible for developing the artifacts for the department as a whole and then I asked for feedback from other instructors in the course. Other instructors made suggestions for modifications to the assignments. The following artifacts were then introduced as assignments in several sections of the "Environment and Society" course in the Fall 2002 semester: 1) Human Population Growth, 2) the Carbon Cycle, and 3) Global Climate Change. Together, these assignments were worth between 10% and 15% of the overall grade for the class.

**Human population exercise.**—Students performed this assignment in a computer laboratory. The instructor began the class with a discussion in which students proposed possible factors that could relate to population growth. The instructor wrote students' ideas on the blackboard and discussed the basic debate over population growth. Students were then directed to the data files on their computers. They were allowed to work in pairs but had to each hand in their own worksheets at the end of the lab session. They were given data from the Population Reference Bureau (http://www.prb.org/) and the World Resources Institute (http://www.wri.org/) describing factors that relate to human population growth and natural resource supply organized in an MS Excel spreadsheet. For each variable that they graphed or analyzed they compared other countries to the United States. This was one strategy for achieving relevance for the students, i.e., by having them think about issues inside and outside their own country. Students compared 25 countries to the United States in terms of the following factors: the rate of natural increase, doubling time for the population, population density, fertility rate, hectares of forest land, and hectares of cropland per 1000 people. Students were required to do basic data analysis and create graphs to illustrate their results. Finally, they were asked to label

Table 1.—Population Growth—Standards of the Indiana Professional Standards Board addressed in the Human Population Exercise. (http://www.state.in.us/psb/standards/ScienceContStds.html)

Population Growth

- Populations grow or decline through the combined effects of births and deaths, and through emigration and immigration. Populations can increase through linear or exponential growth, with effects on resource use and environmental pollution.
- Various factors influence birth rates and fertility rates, such as average levels of affluence and education, importance of children in the labor force, education and employment of women, infant mortality rates, costs of raising children, availability and reliability of birth control methods, and religious beliefs and cultural norms that influence personal decisions about family size.
- Populations can reach limits to growth. Carrying capacity is the maximum number of individuals that can be supported in a given environment. The limitation is not the availability of space, but the number of people in relation to resources and the capacity of earth systems to support human beings. Changes in technology can cause significant changes, either positive or negative, in carrying capacity.

a world map to indicate regions with higher rates of population growth and those with lower growth rates.

*Pre-service teachers:* For pre-service teachers, this artifact-assignment meets two specific IPSB standards for the teacher licensure in the life sciences: 1) Population Growth, and 2) Natural Resources. Pre-service teachers were instructed to keep this assignment for their future electronic portfolios. The state standards addressed by this activity are shown in detail in Tables 1 and 2.

*Relevance for all students:* The Human Population Growth assignment was used to promote the environmental literacy among all students. The assignment served to promote greater awareness of geographic regions of the world as they relate to the concepts of developing and developed countries. Students learned how population growth patterns and access to natural resources help to define nations into one of the two categories. Students became familiar with viewing spreadsheets of data and creating graphs and charts to illustrate basic population concepts, e.g., population density. Students were required to use their critical thinking skills to try to detect patterns in the data. For example, they were asked to summarize the assignment with the following: Based on your answers, what in general do you observe? In which areas of the world is the population growing most rapidly? In which areas of the world is it growing more slowly? Do different areas of the world vary by their access to resources, like forests and cropland? Are there any patterns between population growth and access to resources? Write a two-paragraph summary explaining the trends you have observed in the data provided for this assignment.

**Carbon cycle and global climate change exercises.**—Another important debate covered in the environmental science course is that of global climate change. However, before students can understand the complexity of the debate, they first need to understand how carbon cycles through the Earth's systems. Thus two assignments were created—a take-home assignment on the carbon cycle and a laboratory simulation assignment on global climate change. They addressed the Natural Resources standards for pre-service teachers (Table 2) as well as other IPSB standards for Geochemical Cycles and Environmental Quality.

In the Carbon Cycle activity, students addressed several scientific concepts in a take-home assignment. They discussed the states of matter and the reservoirs for carbon compounds on Earth, namely living resources (organisms), soil and mineral resources (solid Earth), air resources (atmosphere), and water resources (freshwater and saltwater reservoirs). This activity encouraged them to think of carbon compounds as part of their everyday lives, e.g., carbon dioxide that they exhale, carbohydrates as a source of food, hydrocarbons which provide fuel for their cars, for electricity and heat in their homes, and limestone (calcium carbonate) as a raw material for buildings. In their assignments, students applied basic science principles to the cycling of carbon through photosynthesis and aerobic respiration, the formation of limestone and fossil fuels, and the production of carbon dioxide from fossil fuel use, which is a concern in the global climate change debate.

Table 2.—Natural Resources—Standards of the Indiana Professional Standards Board addressed in the Human Population Exercise. (http://www.state.in.us/psb/standards/ScienceContStds.html)

Natural Resources

- Human populations use resources in the environment in order to maintain and improve their existence. Natural resources have been and will continue to be used to maintain human populations.
- The earth does not have infinite resources; increasing human consumption places severe stress on the natural processes that renew some resources, and it depletes those resources that cannot be renewed.
- Humans use many natural systems as resources. Natural systems have the capacity to reuse waste, but that capacity is limited. Natural systems can change to an extent that exceeds the limits of organisms to adapt naturally or humans to adapt technologically.

A computer simulation model was given as an in-class laboratory assignment following the completion of the students' carbon cycle assignments. Hothouse Plant is a global climate change simulation available through EME Corporation (2003). For this assignment, students worked at computer stations in the departmental computer classroom. They explored greenhouse gases and did experiments in which they changed the concentrations of greenhouse gases through data manipulation. They predicted changes in sea level and temperature and related these numbers to specific cities and regions of the United States, for example, dry land loss in coastal regions. They also explored the predicted effects of volcanic aerosols and solar radiation on changes in atmospheric temperatures. The simulation model, combined with the carbon cycle assignment, was designed to help students reflect on the impacts of daily human activities as they relate to the debate over global climate change.

**Assessment.**—Grades were compared for science and non-science majors in one section to assess the new assignments introduced in the Fall 2002 semester. For the Human Population Growth assignment, the average grade for non-science majors ($n$ = 23) was 86%, while the average grade for the science majors and pre-service science teachers combined ($n$ = 6) was 92%. For the Spring 2003 semester, the average grade for non-science majors ($n$ = 23) was 85%, while for the science majors ($n$ = 5) it was 90%. The non-science majors may be at a slight disadvantage in this assignment. Students gave the instructor feedback on the assignment. Verbal comments suggested that making graphs of data was unfamiliar to both science majors and non-science majors, therefore it was important for all students to practice these skills. Students indicated that they thought this was a challenging assignment.

When examining the Carbon Cycle assignment grades for Fall 2002, science majors and non-science majors scored on average an 88%, indicating that the content is suitable for both groups. For the Global Climate Change laboratory assignment, the average score for non-science majors was 90% versus 89% for the science majors. In general the comparison of grades suggests that the basic science content for the three artifact-assignments is suitable for students in the class regardless of their majors.

Faculty members teaching the course also assessed the assignments for suitability in their individual courses. For those with sections larger that 32 students, the Human Population Growth and Global Climate Change exercises designed for the computer laboratory can create a problem because there are only 32 computer stations in the department. Instructors in these larger sections have discussed using the assignments as take-home assignments, giving the responsibility to the students of finding computer facilities on their own. One problem with this approach is that students sometimes like to ask questions of the instructor while completing the assignment, such as in a laboratory setting. These and other issues related to the new assignments are continuing to be addressed in discussions among instructors of the course about using them in the future.

## DISCUSSION

A university-wide pre-service teacher initiative began in the Fall of 2002. There was a need for documentation of science content learned by pre-service teachers pursuing a life-science licensure. Artifact-assignments connected to state standards were the requirements for achieving this goal. However, artifacts were also designed to serve an additional purpose, namely as assignments for all students enrolled in the introductory course. When the new assignments were proposed to the five instructors of the course, an important issue was the freedom for each instructor to follow a preferred procedure. In assessing the implementation of three new assignments in the "Environment and Society" course, the five instructors who teach the class decided to use them in very different ways. Some instructors used all three assignments, while other instructors used one or two of the assignments. Further, some instructors required the new assignments of all students enrolled in the class, while others gave the artifact-assignments only to the pre-service teachers as extra assignments to be completed outside of class. Thus, there was healthy debate surrounding how these new assignments should be used in the department.

The strategy that has been discussed throughout this article has been to use the pre-service teacher initiative at Ball State University to introduce assignments for all students in an introductory environmental science course to develop their environmental literacy. The content of the assignments was intended to incorporate basic scientific principles that U.S. citizens should know to understand environmental debates and that was deemed appropriate regardless of the students' majors. The discussion presented above was one possible strategy for combining the goals of a science department for the students it serves with the goals of a university for pre-service teacher development.

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