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PROBLEM BASED LEARNING: OBSERVING THE EARTH

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1. INTRODUCTION

Within a university core curriculum non-science majors are typically required to complete a minimum of one lecture course in the sciences (sometimes with an accompanying laboratory session). In these situations, motivation in a course is of key concern as students may then be simply fulfilling a requirement. In addition to this possibility, students in this situation are often characterized as somewhat fearful and/or disinterested in science. Much anecdotal information implies that very often they have also waited until late in their college career (e.g., their last semester before graduation) to satisfy the university requirements for graduation.

Although students may have a variety of options to fulfill their science requirement, many universities offer general education service courses to accommodate the demand. In order that students meet their science requirement, the Department of Geology and Meteorology at Kean University offers a variety of courses including “Observing the Earth”, a three credit hour lecture course. This course provides an overview of content from the broader fields of astronomy, geology, meteorology, and hydrology and is intended as a foundation for further coursework as appropriate. Ideally it is suited for both collaborative and cooperative learning strategies as it is focused more on inquiry-based, rather than laboratory-driven, learning methods.

The intent is to provide a basis of the underlying facts and principles of Earth systems from both a universal (i.e., astronomical) and geocentric point of view. Unfortunately, the course can only provide glimpses of the depth and breadth of the scientific disciplines and their interconnectedness and does not have a separate laboratory component. Therefore, it is difficult not only to develop a content knowledge base, but also students’ scientific literacy and their ability to apply the scientific thought process in a situational context.

In order to rectify these shortcomings, the problem based learning approach was applied to all facets of the course to enhance comprehension and retention of content as well as to provide real applications that could relate to each student’s major of study. In this manner they could find greater motivation and more readily develop analytic skills.

2. DATA, METHODOLOGY, & ANALYSIS

During the fall and spring semesters (of the 2004-2005 academic year), problem based learning strategies were incorporated with the author’s “Observing the Earth” class sections in terms of in-class lectures, assignments, student-based geosphere briefings (and collaborative learning), and a final student group project presentation (and cooperative learning) and discussion. Each of these were oriented in such a way that the final project presentation would require synthesis of both content and context of scientific information, science, and the critical thinking required to use these to solve a major problem composed of many (often competing and/or contradictory) parts and elements.

a. Course Structure & Design

The course was therefore structured to include the following graded elements: in-class participation and discussion; active learning strategies and thought experiments; online investigations and assignments of reading and writing; geosphere briefing teams; and an end of semester group geosphere project for presentation and discussion. Each of the first four elements was intended to provide different skills development (as discussed below) as well as repetition and practice that would be useful in the fifth and final element of the course. Each element was assigned a grading weight, in sum worth more than half their final grade, in order to provide for substantive motivation for students. All course aspects entailed varying degrees of individual, cooperative, and collaborative learning and used a variety of learning styles whenever possible.

In-class participation and discussion were designed to relate the importance of making

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observations of the natural environment, and their categorization, to the student's own learning process. These were also helpful in determining how various associations and relationships are established from empirical evidence and statistical analysis. Discussion allowed for sharing – and also served as a very important calming effect for non-science majors – and the formation of a common foundation for the class to build upon. The use of active learning strategies and thought experiments relied on the use of various "props" (or "live" material samples) and the immersion of the class in the scientific process. This was necessary not only given the lack of a laboratory component, but also because of the necessity for the students to make use of their own cognitive abilities and learning styles.

Online investigations and assignments provided students an opportunity to gather and reflect upon additional content and to discern discrepancies and/or inaccuracies. These were important to provide a backdrop to what science is "supposed to be" (i.e., replicable, completely objective) and what it is in reality (e.g., opinionated, contentious) and assisted student comprehension of the concept of "good" versus "bad" science.

Assignments included writing to reflect upon content, context, and subjectivity found within our analysis of all natural systems – particularly when they impact the biosphere (or vice versa). Student groups then had opportunity to practice each of these in their preparation and delivery of a geosphere briefing in which they highlighted current and relevant universal, geologic, atmospheric, and hydrologic information, findings, and applications.

Based upon the foregoing, students were involved in critical reading, collection and/or analytic examination of data (e.g., observe, hypothesize, theorize), and the application and relation of course content to real-world situations (e.g., natural resource allocations, human responses to hazards). Therefore, an understanding of the complexity of the geosphere system, particularly when any aspect of the biosphere is involved, is the driving principle of the course.

By design, students should more clearly identify and experience the relationships between natural systems and the reaction and interaction of biosphere systems with them. In principle, students would learn content, develop principles, apply the scientific thought process to known solutions, and consider these relative to "non-scientific" issues (e.g., socioeconomic, political, cultural, and others).

b. Group Project & Strategies

While many problem-based learning strategies were used within the course framework and day-to-day structure as stated above, the focus of this paper is the final group project presentation completed during the spring 2005 semester. The project was first introduced through the course syllabus and then repeated during the first four weeks of the term with an indication that more information would follow. The delay of providing full project details to the students was intentional and meant to allow for the initial development of both the content and skills the students would need to make use of when completing the project. This included the in-class discussions and thought experiments as related to the big bang theory, the geocentric versus heliocentric universe, the classification of minerals, geologic time, and plate tectonics (e.g., many students found it very difficult to be in the position of proving an established precept such as a heliocentric solar system).

During the first four weeks, content knowledge, scientific reasoning (deductive and inductive), the development and testing of theories (including hands-on testing of materials and their physical and chemical properties and behaviors), and the application of science, technology, and scientific principles for problem-solving, avoidance, mitigation, and prevention were crucial. These same facets were then applied for all remaining topics during the semester and could be used by student groups in their geosphere briefings during the term and in their online investigations needed for their assignments. This allowed students to practice their analytic and assessment skills for decision-making prior to their final project presentation. It also provided ample opportunities for feedback, correction, and collaborative learning.

Upon completion of this portion of the course, students were then ready for the driving question of the group project which made use of a very recent (and very horrific) natural disaster – the Asian tsunami of December 2004. Using this event students were asked to form their own groups (of no more than four students) to answer this question: How is the rebuilding response of a nation, impacted by a major natural disaster (e.g., a tsunami), determined and how is the success and appropriateness of that response measured? Each group was then charged with applying themselves to learn, use content knowledge, find problems, develop ideas, make decisions, and take action in order to answer the question. All groups were expected to maintain a positive interdependence, individual accountability, share in leadership, and act as a team in completing and presenting their project by the end of the term.

In essence, each group was required to provide a detailed plan for the rebuilding of any country destroyed by the tsunami. The students were also advised that they would be in competition with one another for grading purposes. To assist teams in getting started, some class time was provided for familiarization among members, identification of tasks (by group members), and discussion of expectations, their plans for the work, and how they intended to deliver their findings. In addition, each group was tasked with the completion of several overarching questions based on their online text readings and course content. These questions were intended to broaden student and group perspectives, provide them a "test-case" of group dynamics, and to avail them an opportunity to resolve complex issues based on science, policy, and "non-science" issues. They also required substantive understanding of the principles of, and limitations imposed by, the universe and the geologic parameters, atmospheric principles, and hydrologic realities of the Earth system.

These same aspects were also critical to each group's ability to analyze a given situation and apply the "Know-Care-Act" mantra of the environment (reference here); and to consider the competition that exists between ethics and economics and "good" versus "bad" science (reference here). The synthesis of these required focus, relational assessments and thinking, development of alternative solutions and scenarios, an ability to assess the efficacy of proposed actions, a flexibility to accommodate unexpected changes or controlling factors, and the ability to critique findings (from a scientific process and viewpoint) prepared by the group (as well as those of other groups). Students therefore had to provide appropriate justifications based upon scientific reasoning, knowledge and applications, available technology, socioeconomic, cultural, ethical, and other considerations and be prepared to defend their own arguments during presentation.

c. Outcomes & Assessment

Student groups were provided time in and outside of class during the seventh through eleventh week of the semester to pose, answer, and refine their questions and develop their final project presentation. Their assignments and other course elements, including their final presentation, were the artifacts used to determine grading whereas assessment surveys were completed at the end of the course. Groups were to provide evidence for their solution, state their case clearly and completely, assess the effectiveness of their solution, and provide a means to test its effectiveness and robustness. Grading of their project presentation (and that of individual students) was based on: Content and Reasoning; Application and Demonstration; Viability and Robustness; Presentation and Self-Assessments.

Each of these were considered according to the resources available to the student from the course, their ability to relate and integrate their work with course content, and the proper application of science, use of the scientific approach, and scientific literacy. While students were not graded according to their own presentation abilities, it was important that the group presentations were coordinated, inter-related, and understandable. The presentation was therefore also considered with regard to its precision, conciseness, and how convincing were the supporting arguments and solutions. Each student was also expected to respond to any queries for clarification, furtherance of topic or solutions offered, and to test their content knowledge.

3. CONCLUSIONS

Accomplishments of the course and its impact on students will be further examined during its implementation during the 2005-2006 academic year. Plans for future include any revisions that may enhance both hands-on and thought-experiments performed by the students, the possible use of blogs for tracking purposes, and other items. These same techniques may be applied in other situations and/or other courses within the curriculum as well.

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