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TECHNOLOGY & RESEARCH INTEGRATION – AN ATMOSPHERE OF LEARNING FOR STUDENTS (TRIALS)

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1. INTRODUCTION

Engaging undergraduate students in college classrooms is more often grounded in a variety of pedagogical methods and tools that take advantage of learner types and cognitive strategies. These include problem-posing and solving as well as inquiry-based activities – especially those involving hands-on principles to illustrate important processes. However, many of these are limited to the classroom setting and may not provide adequate use of multimedia or other technology in a sustainable manner.

Although such pedagogical methods are now in more common use throughout education, owing to the numerous studies of methods over the last twenty years – particularly in assessments, their application in the classroom has not necessarily been greeted with enthusiasm by students. Classroom dynamics and prior 'training' of 'how to learn' tend to inhibit student performance and acceptance of different methods in their coursework. This naturally limits their effectiveness. In addition, as courses may be selected on the basis of fulfilling the core requirements of the university a student's stake in the class mechanics may be very limited.

Based on these factors it is not unusual for students to approach their coursework with attitudes such as: "Tell us what to know" (content); "Tell us what to do" (context); "Tell us why to do it and why in that way" (motivation, decision-making, justification); "Tell us how to do it [precisely]" (methodology); and "Tell us what the answer is that we should 'get' and that you 'expect' from us" (outcomes, testing, assessment, and grading). In other words, students have learned how to learn according to expectations of the course and grading structure for material that is presented in a standard and compartmentalized manner.

In an effort to avoid these simplistic attitudes towards the learning process, a prototype "TRIALS" program (Technology & Research Integration – An Atmosphere of Learning for Students) was initiated at Kean University. In particular, the problem based learning (PBL) approach and other methods were employed in several courses with various technologies in order to maximize impact on student learning. The intent was to provide earth science majors, including teacher education and non-science majors opportunities in lecture, laboratory (including demonstration), and group and term projects to work on realistic problems by integrating content with context while using select instrumentation as part of the learning process.

2. TRIALS COURSES

The TRIALS program was initiated during the 2006-2007 and 2007-2008 academic years in each of the lower division courses – designed for first and second year students: Introduction to Meteorology (METR 1300), Observing the Earth (ES 1000), and Research and Technology (GE 2024). These courses also attract third and fourth year students who must complete a science (or science with lab) requirement prior to their graduation and thus are populated by a diverse mix of majors and class years. While several methods and applications were made for each of these courses (with some courses offered each of the four semesters of implementation), select examples are provided here for illustration.

The METR 1300 course is designed to provide students a structured study of the atmosphere according to its components, characteristics, and behaviors as related to the sensible weather conditions. A sequenced study of atmospheric chemistry, radiation, and energy transfer is followed by examination of moisture and stability. The course is completed by the study of wind, pressure, forces, and the concepts of forecasting and numerical weather prediction. Aside from lecture twice a week, the course features a three hour laboratory session in which students apply various principles to learn more about how the atmosphere works.

The ES 1000 class is designed for non-science majors to learn about and understand the

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context of scientific information as it relates to the geospheric components. The twice per week lectures are sequenced based upon an initial examination of the role of the Scientific Method and science in society, the “Know – Care – Act” philosophy, and the application of knowledge to “Avoid, Mitigate, Prevent (AMP)” natural and other hazards. These arise from an overview study of astronomy, geology, meteorology, and hydrology. Lectures are often highlighted with thought-experiments and short demonstrations of principles to help students associate physical and sensible observations of a qualitative nature with quantitative information that is necessary for decision-making and applications.

The GE 2024 course is designed to prepare students to plan and conduct independent research as related to their major. While various sections are geared to specific colleges within the university (i.e. science versus liberal arts), the mix and diversity of students within a given college is helpful in that it provides students with insights to the many variations that may occur in a research environment. The course is structured to prepare students for research by an iterative process of formation from guiding questions and hypotheses to literature reviews and development of methodologies. At the end of the course students submit a final research paper (in appropriate peer review journal format) and present an oral and poster presentation of their work.

3. METHODS

The Problem Based Learning (PBL) approach was employed for each of these courses in order to initiate learning through the use of a posed problem, query, or puzzle to be solved. While other methods were also used (e.g., to allow for learner types), the PBL approach includes the use of small teams or groups, the development of multiple and multidisciplinary skills, and often demands students work collaboratively to establish an interdependence. Many of these methods may be applied throughout a semester as well as during a sequence of lectures and laboratories depending on the need for each course.

The PBL approach involves acquisition and use of content in specific contexts, the definition, collection and analysis of data; the consideration of a conceptual framework for qualitative and quantitative modeling, and applications of the knowledge to new situations or experiences. Clearly PBL is not easy nor “what the professor wants” from the student perspective as it challenges them to develop a “Habit of Mind” that requires problem finding and solving. The approach is to some extent self-directed which allows for experiential, cognitive and complex exploration by each student. This is realized through guided inquiry, hands-on use of technology, and situated learning experience that are comprehensive.

In the case of METR 1300 a laboratory exercise was used to help students learn and better understand the importance of data, its collection, the role of metadata, evaluation of the data’s “worthiness” and proper (or improper) interpretation. This exercise involved the use of PASCO sensors which included probes to measure air temperature, sunlight, and soil temperature. The laboratory was the third in a sequence and was preceded by two labs that focused on weather observation methods, weather data plotting in time and space, and the use of sensors to associate quantitative information with qualitative observations. Underlying principles include the need for observational, instrumental, and network criteria when measuring and assessing thermal variations.

The three weeks of lecture that preceded the lab included content on the chemical composition of the atmosphere and its role in the observed vertical thermal profile; the nature and type of radiation from the sun and its receipt by the Earth-Atmosphere system; the role of geometry in the amount of insolation received; the process of warming the atmosphere based upon the principles of energy transfer (reflection, absorption, transmission, and scattering); how this process relates to the observed distribution of temperature regionally in space and time; and the relation of these to the greenhouse effect and global energy. Each of these plays a role in explaining observed thermal variations and helps to define appropriate and accurate measurements.

In ES 1000 a group (or team) project was assigned to be prepared over a five week period. Although first introduced at the beginning of the term as a component of the course (for grading), the Earth Team project was not elaborated upon until the fifth week of the semester. This was after several in-class demonstrations and activities that focused on sensor concepts (i.e. remove human bias of observation, the need for remote observations, use of automated measurements, and the role of metadata). Each of these was related to the nature of the Scientific Method and its application to real situations. This included consideration of the same for course content on geology (and other topics). From these experiences students were tasked with designing an appropriate observational strategy of geosphere components as found in the campus ecosystem.

Over the next five weeks the student groups (Earth Teams) were responsible for collecting, analyzing, and interpreting data and observations of the lithosphere, atmosphere, and hydrosphere as well as biosphere interactions. This was accomplished using PASCO sensors (temperature, pH, conductivity probes) and other instrumental or observational techniques as determined by the groups. These were used to determine impacts of the geosphere on the (primarily human) biosphere on campus as well as biosphere impacts on the geosphere components found in the campus environment. Based upon their findings, the groups were to offer their analyses, problems and/or impacts identified, and their solutions based upon application of the Scientific Method. Earth Team presentations were made by each group during the last two weeks of the semester.

The GE 2024 class also made use of the PASCO multi-parameter hand-held sensors as part of a semester long research project culminating in students presenting their results (orally and in poster format) and submittal of a research paper. Students were provided a sequenced guide to the development of a research topic and the methods necessary to perform a research project. This included an overview of the research process with regard to ethical issues, motivations for research, the identification of research tools, use of the literature and Internet as well as associated databases; and the identification of a problem and formulation of the questions related to finding its solution. Research strategies were pervasive in this material over the first six weeks of the term and provided students with their research topic of study.

During the following six weeks of the term, students pursued the design planning, implementation, and deployment of sensors for campus-based observations. The intent was to prove a hypothesis about their chosen research topic that involved the outdoor campus environment when considered as an urban ecosystem. Their data collection was related to both reference sites available on campus and to observations of human behaviors or activities for correlative purposes. Analysis focused on statistical and graphical techniques (including spatial and temporal variations and variability) in order to justify their methods as well as prove their hypothesis. During the last two weeks of the term students presented their work in order to prove what they had designed and studied by direct observations, hypothesis testing, trials and/or experimentation, and the collection of data and metadata for analysis.

4. OUTCOMES & RESULTS

Each of the courses designed for use in the TRIALS implementation required the answer to two questions: “What is it you want your students to learn?”; and “What is it you want your students to be able to do?”. The implication of these is that students are expected to acquire base content knowledge as well as specific situational knowledge that may be used in a constructivist manner to identify and address an issue or problem in the physical world and resolve it by one of several methods. This is possible regardless of a student’s science or non-science background.

The development of this “Habits of Mind” is critical in that it implies that when students are “released into the wild” they will remember and be able to perform the steps necessary in real world settings. The complexity of real world problems and the decision-making process provides a testable assessment of these principles. It also helps to illustrate the complexities of the environment and how it is observed, assessed, monitored, and predicted in spite of human biases. These realities are important to the learning process.

In the laboratory session of METR 1300 the intent was for students to learn the uses of technology to not only represent physical reality as sensed by people, but also how to use that technology to generate data that is truly representative in time and space. Based upon these principles, students would then be able to properly observe and assess thermal variations and identify their root causes as related to the features observed in thermal distributions. This would also be true of alternative scenarios (e.g., weather situations) that might create different modes of behavior. These findings lead to practical skills development that the students may use in many situations they encounter.

The Earth Team projects in ES 1000 were intended to provide students insight to the complexity of the geosphere environments in which we live. It is the complex connections and interactions within and between the various geosphere and biosphere (human and other) components that make the base topics and material (e.g., geology, meteorology, and hydrology) seemingly so formidable to understand. Yet when given an opportunity to express and measure the basic features and processes involved, students are able to take “ownership” of issues in a more personal manner and apply scientific methods and principles with a greater degree of comprehension. This allows them to also weigh the relative importance of non-science factors such as economic, political, social, cultural, and ethical issues which are part of the decision-making process.

Students in the GE 2024 course are expected to have the ability to independently plan and conduct research once they have completed the semester. While a lofty goal, the point is that through a variety of PBL and related experiences they are direct witness to the difficulties inherent to the research process. Thus the course requires that they learn multiple pathways to problem finding and solving and that they consider alternate points of view, particularly as offered by the peer reviewed literature. Each of these provides opportunities to learn about critical review and how the scientific process plays a role in all phases of research endeavors. Once immersed in this manner, students are not only self aware of their work, but able to more critically analyze the work of others – a skill necessary for the conduct of research.

For each of the classes in which TRIALS was implemented, opportunities existed for students to try and fail – in order to succeed. This included the use of sensors, data collection and manipulation, data analysis and interpretation, written reports or papers, and the presentation of their work. The methods demanded critical thinking rather than the rote use or application of standard theory to identify and answer questions about their selected topics. These also often required the use of external resources or information to help justify their approach, findings, and solutions. In most cases, cooperative and collaborative learning were essential for students to progress in their work in a meaningful and in-depth way.

5. SUMMARY

The application of PBL and other pedagogy was accomplished through the Kean University "TRIALS" program. However, the success of the implementation was highly dependent upon having a comprehensive view of how the methods tie-in or relate to the intent of a course, specific lessons, basic content, and the context or situation in which it is to be applied. The ability of students to understand qualitative and quantitative observations, metadata, and how to analyze and interpret data are key to assessment of their learning. These serve as a basis for them to comprehend time and space issues, the value of reference sites and peer reviewed literature, and most importantly to be able to know what the correct outcome is and why – with confidence.

The proper design and layout of each course and of the class sessions, whether lecture, laboratory, or project; requires attention to the outcomes used for grading and assessment. These are further defined by the metrics based upon student artifacts that reflect the development and use of technical and multimedia skills, communications, and their integration. For the courses used at Kean University, the incorporation of the Institute for Urban Ecosystem Studies program was important in providing focus for the Environmental Assessment and Environmental Impact Statement approach.

Feedback from students involved in the courses and activities (obtained through both surveys and informal discussions) was generally positive. The ability to "do" science and perform real observations and experiments allowed them opportunities to learn in their own frame of reference – and to some extent at their own pace. While time spent in groups was somewhat less productive in the view of some students, most indicated that these instances did provide them with a deeper understanding of, and ability to see, other points of view and strategies that could be used in problem identification and solving.

Getting students to think critically and acquire both content and an ability to synthesize material is not a trivial task. However, the application of these methods for K-12 audiences is not difficult if considered in the context of prolonged and repeated exposure through several courses. The more pervasive the techniques – and expectations – the more readily students will learn and acquire skills in technology and research that are self-sustainable with time. It is in this manner that students learn not only to ask probing questions, but the "right" questions to ask in the process of exploration. These naturally lead them to the use of various resources and "deeper" questions that require application of content and skills in the proper context, and a synthesis of material to develop solutions.

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