Watershed Analysis and Teacher Education Resource (WATER) Project

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Introduction

It has been suggested that engineers could focus on professionalism by pursuing activities that directly enhance the engineering profession such as working with organizations and universities to promote K-12 education in science, engineering, math and technology [2]. Science and mathematics classes in the K-12 arena are considered gateways to the engineering profession [1] and can provide the context that students need to make the application of fundamental math and science relationships to solving real-world engineering problems. Programs are needed in the K-12 experience that deliver hands-on, project-based curricula providing the opportunity for K-12 students to experience the wonders and opportunities of education and careers in engineering and technology [1].

K-12 teachers typically have not majored in the science field of the courses they teach. Also, in the United States students are less likely than students in other countries to be taught science by teachers with a major area of study in science [3]. Generally, across all countries, only 20% of students are taught science by teachers who believe that they are well prepared. The US teachers generally report higher levels of confidence than other countries, but only 27% of students in the US were taught by teachers with a high level of confidence in their preparation [3].

The universities participating in this research are located in the northwestern part of Ohio in counties that are characterized by small towns and predominantly agricultural areas. Many of the students in these small K-12 systems do not have the opportunity to consistently be taught by teachers that have been able to specialize in math and science. Hence, we need to reach out to these rural school systems to increase the students' awareness of their opportunities to move into technical and science careers.

Watersheds are ready-made natural science and math laboratories. Within the confines of a watershed study we can explore and mathematically quantify the fundamental physical relationships of size, shape, length, area, slope, water velocity, and flow. We can demonstrate the calculus concept of area integration and combine it with velocity measurements to determine flow rates. There are abundant opportunities to demonstrate data collection, precision, accuracy, and statistics. We can measure and monitor chemical and biological reactions and natural populations. We can demonstrate mass balance concepts and teach the difference between concentrations and mass loadings. The watershed provides the interface between water, earth and the atmosphere, and we can measure and quantify many of the equilibrium relationships that affect our world at these interfaces. All of these concepts can be presented in the context of environmental sustainability and with evaluation of socio-economic impacts of our environmental regulations.

Ohio Northern University (ONU), University of Findlay (UF), and Bluffton College (BC) are three independent liberal arts colleges in northwestern Ohio. ONU has the unique aspect of also having a College of Engineering. ONU, UF, and BC have created a collaborative relationship to develop efficiencies in the offering of an environmental curriculum that meet some of the needs of several different programs at the universities (engineering, science, management, and education). Efficiencies have been developed through initial team teaching and use of innovative on-line resources along with development of an asynchronous learning network to supplement face-to-face teaching. Further the collaboration has developed an outreach to area K-12 teachers to provide them with tools and resources for teaching science and pre-engineering concepts in a watershed context. The outcomes of the university course and a K-12 teacher workshop developed through this grant will be assessed over an initial three-year period. Finally, the course developed has provided an opportunity for service learning for college students and has involved undergraduate and graduate students.

Project Objectives

1. Development of a hands-on project-based environmental course that will be delivered at three universities and will meet cross-over needs of environmental engineering, science, management, and education students at the undergraduate senior level and at the Master's Degree level and provide asynchronous learning opportunities.
2. Development of efficiencies for all three universities through collaboration and use of a combination of Internet resources, asynchronous distance presentations, and traditional delivery systems coupled with on-site coordinators.
3. Development of service learning opportunities for engineering, science, management, and education majors in mentoring K-12 teachers in a hands-on project-based workshop format.
4. Providing tools and resources to K-12 teachers to assist them and increase their confidence in opening the gateways to engineering, science, management, and education careers.
5. Development of assessment instruments to evaluate:
    a. Efficiencies to the universities
    b. Course outcomes for university students
    c. Impact of K-12 workshop on teachers' confidence, and
    d. Workshop outcomes

Implementation Plan

The plan for implementation has relied on the strengths of the faculty from the three institutions. Bruce Berdanier (ONU) and William Doyle (UF) developed the course core curriculum and field and laboratory experience. Berdanier has over 25 years of experience in the technical aspects of watershed study, analysis, and modeling. Doyle has 30 years of experience in environmental engineering and in the socio-economic aspects of environment and sustainable development in industry along with the development of on-line course delivery systems. Gayle Trollinger (BC) developed the K-12 hands-on workshop, along with the lectures for the university course that focus on mentoring of the K-12 teachers for the service-learning component. Berdanier and Doyle assisted Trollinger in developing technical and scientific details to be delivered in the

workshop modules. Additionally, Trollinger took the lead in developing the assessment instruments to be used to evaluate the course and workshop outcomes along with an imbedded assessment tool for evaluating the impact of the workshop on the teachers' confidence to teach science concepts. Further, Trollinger developed and utilized a network of personnel in the colleges of education at the three institutions and outreach to the K-12 teachers in the area school districts. Trollinger has over 15 years of experience in educational methodology and assessment.

Description of Technology Used

1. On-line course management system for students at all three universities.
2. On-line lecture notes, streaming video lectures, and reference materials for asynchronous learning.
3. Real-time teleconferencing of lectures for distance learning.
4. Traditional face-to-face lectures and demonstrations.
5. Site coordinators for directing field and laboratory operations using computerized spectrophotometers and electronic probes for quality control of watershed assessment.

Projected Changes in Operations, Instruction and/or Service

This project has resulted in the first collaborative, on-line, asynchronous course offering by ONU, BC, and UF. This experimental course is being offered in spring, 2003 and will be evaluated for regular offering thereafter. This has been the first time for these institutions to offer a course using shared on-line technology, and the final approved course can be cross-listed for several degree programs. Additionally, this has been the first collaborative effort by these institutions to reach out to the K-12 teachers with science support. The workshop portion of the project has resulted in a proposed annual graduate level course and continuing education workshop for K-12 teachers.

Number of Faculty, Students, and Institutions Affected

This project has directly affected the three universities, Ohio Northern University, University of Findlay, and Bluffton College and the three PIs, Berdanier, Doyle and Trollinger. The initial course offering has directly impacted approximately 30 university students. The number of K-12 institutions involved in the initial workshop cannot be accurately estimated until the end of May 2003. However, we anticipate drawing participants from a three-county area and serving approximately fifty K-12 teachers in the initial workshop offering.

Projected Efficiencies and Cost Savings over a Two to Three-Year Period

The development and successful offering of the course annually should result in cost savings of two faculty salaries each year for one term along with associated fringe benefits. Additionally, the course delivery system should reduce associated overhead costs for the institutions, and the asynchronous learning aspects of the course may provide enough flexibility to encourage additional students to take the course providing additional income for the universities. After the first grant period offering of the course, the three universities will have to determine a methodology for sharing student income, assigning faculty FTEs, etc.

Potential for Replication

There is a high potential for other institutional collaborations to replicate this model. The course materials will be documented in an on-line course management system, which could be used as a model for other institutions. Additionally, other math and science topics could be built around a project based course and workshop format, which would allow university students to mentor K-12 teachers and to help increase the teachers' confidence in their subject matter. Further, a workshop manual will be developed and given to each of the workshop participants, allowing them to duplicate all or portions of the workshop activities with future students or other teachers.

Evaluation Plan

Gayle Trollinger is working with educators from ONU, Findlay, and Bluffton to develop a two-part assessment instrument for use in the project. Participants in the K-12 workshop will complete a scaled survey at the beginning of the course and at the end that focuses on their confidence in teaching the subject. The quantitative data from the survey will be enhanced by the second part of the assessment, that of written reflective journaling. Teachers will be asked to reflect on their perception of their confidence in teaching and how participation in the course enhanced (or did not enhance) their confidence. Teachers will also be asked to reflect on learning in their classroom that resulted from implementation of content and pedagogical strategies gained through their participation in the course. These reflections will be posted on the course management system for review by all participants and will be included in the materials developed as a result of the project. Finally, participants will be asked to reflect on the delivery of the course and whether it was accomplished with efficiency.

University students at ONU, BC, and UF will be given a list of the expected course outcomes at the beginning course and will complete a scaled survey at the end of the course to provide data for a quantitative assessment of the success in meeting expected course outcomes. The project PIs will compile all data from the course and workshop assessment instruments along with examples of course materials, handouts, lectures, and examinations in a project outcome notebook. This information will be presented to the project evaluation team at the completion of the course and workshop.

A three-member team composed of one person from each institution will complete the comprehensive evaluation of the project. The evaluation team will include science and education faculty. Members of the team will meet for one half day to review the objectives of the project, the project timeline, and the project budget and to prepare the evaluation report. Quantitative and qualitative data will be examined and synthesized and a final report will be written for submission by June 1, 2003. In addition to data from the project, members of the evaluation will include suggestions for on-going implementation of the program. The final report will be submitted to appropriate college deans at ONU, BC, and UF for review and consideration of the course to be approved for delivery by science and education as a regular course offering. Also, the workshop will be reviewed for approval to be delivered as a one-hour graduate level class for K-12 teachers and to be offered as a continuing education workshop on an annual basis. A copy of the project outcome notebook and the evaluation team report will be presented to the Vice President for Academic Affairs at each university. The project PIs will request a working

committee be formed with representatives from each university to work out the administrative details for regular offering of the course and workshop.

Future Extensions of the WATER Project

The WATER project assessment and evaluation will be submitted to FIHE in June 2003 for consideration of an additional year of funding for the 2003 – 2004 school year. At this time it is anticipated that the format of the course and workshop along with service learning will remain essentially the same. The course will be proposed to be expanded by adding a Geographic Information System (GIS) component. It is proposed at this time that this change will necessitate the expertise of one additional faculty member from ONU to teach and direct the development of mapping and online databases within the watershed concepts. K-12 teachers will be introduced to the concepts of mapping, databases, and graphical presentation in the teaching of math and science in the watershed context.

Bibliography

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