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1. INTRODUCTION

Water in the Earth System (WES) is the newest distance-learning teacher enhancement course designed, developed, and offered by the American Meteorological Society (AMS) and funded by the National Science Foundation (NSF). The primary focus of WES is the transfer and transformations of water and energy in the global water cycle using an Earth system science perspective and inquiry-based methodology consistent with the goals of the National Science Education Standards. Through a unique paradigm, WES integrates and applies fundamental concepts of meteorology, oceanography, and hydrology to build basic scientific understandings and to explore societal implications of local and regional changes in the global water cycle (Geer *et al.* 2002).

The principal activities of WES are threefold: (1) development of scientifically authentic and pedagogically appropriate educational materials, (2) training teachers to assist in the peer-instructional process as members of Local Implementation Teams (LITs), and (3) delivering instruction to teachers enrolled in the course. Teachers who successfully complete WES earn three hours of graduate credit from the State University of New York (SUNY) at Brockport and present their personal “plan of action” to serve as WES resource teachers in their schools and school districts.

Development of WES began in 1999 using the highly successful DataStreme Atmosphere Project (formerly called the

DataStreme Project) as a model for delivery of instructional materials, including near-real time environmental data via the Internet (Weinbeck *et al.* 2002). Preparation for the Fall 2001 national implementation of WES involved (1) writing of instructional materials and construction of the course homepage, (2) training of LIT leaders, and (3) pilot offering of the course for all LIT members during Spring semester 2001 (Geer *et al.* 2001). Through Spring semester 2002, 36 LITs located in 33 states have offered the course to a total of 598 teachers. By the end of the NSF funding period, more than 1600 teachers nationwide will receive direct WES training. Thousands more teachers and students will benefit from peer training by WES alumni.

Approaching the midpoint in the national implementation phase of WES, this is an appropriate time to evaluate the performance of the course and its effectiveness in accomplishing its stated goals. This paper examines the course to date based on formal feedback from both LIT members and teachers who have completed the course. We begin with a brief status report of ongoing materials development and LIT training.

2. MATERIALS DEVELOPMENT

Internet delivery of many of the WES course components provides learning experiences that are continually updated. Participating teachers report that this timely aspect of the course is particularly useful and compelling.

The 12-chapter customized WES textbook serves as a reference in support of twice-weekly investigations. The WES study guide contains the first part of each of these investigations. AMS education staff writes the second part of each investigation to recent

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environmental data. This online component of the investigation is posted to the course homepage by noon eastern time on Tuesday and Thursday during each of the 12-weeks of course offering. In addition to investigations, the WES course homepage includes links to Earth system, atmospheric, oceanic (and inland seas), and terrestrial (hydrological) information. Links are regularly monitored and added to where appropriate.

A special feature of the course homepage is the *Weekly Water News* that includes a compilation of current events from around the world relating to water in the Earth system (along with links for more complete coverage), the concept of the week that explores in some detail a topic related to that week's central theme, and a listing of this-date-in-history events having a focus on water. The *Weekly Water News* is posted on Monday mornings and updated throughout the week. Also delivered weekly via the course homepage is *Supplemental Information*, an in-depth discussion designed to enrich or update a major scientific topic of the week.

3. WES LIT TRAINING

A WES Local Implementation Team (LIT) is composed of two master teachers recruited from the cadre of teachers who had participated either in Project ATMOSPHERE/ DataStream or the Maury Project plus a scientist (e.g., National Weather Service hydrometeorologist) or college professor (Geer *et al.* 1999; Geer *et al.*, 2002). LIT members mentor participating teachers, communicating with them at least once weekly via fax, phone, or e-mail, and meeting face-to-face at the beginning, middle, and end of the course. Each LIT typically mentors a total of 8 teachers.

LIT leaders attended three summer workshops (Annapolis, MD in 2000, Madison, WI in 2001, and State College, PA in 2002), where they received training on a variety of topics in meteorology, oceanography and hydrology. The first two workshops are described in Geer *et al.* 2002. Climate and water was the major emphasis of the Summer 2002 four-day workshop hosted by the Department of Meteorology at Pennsylvania State University. The 2002 workshop program consisted of lectures, laboratory demonstrations, group discussions, and a field investigation. Lectures included "Climate and the Ice-Core Record," Richard Alley, Pennsylvania State University; "Global Climate Change and Sustainability," Eric Barron, Pennsylvania State University; "Ocean Circulation and Abrupt

Climate Change," Klaus Keller, Pennsylvania State University. Participants toured Penn State's weather facilities and participated in a stream gauging demonstration on nearby Spring Creek, directed by David R. DeWalle of Pennsylvania State University.

4. ASSESSMENT OF WES

The impact of WES has been assessed in two ways: (1) evaluations are given to participants at the completion of each semester to gauge their satisfaction with the course and its components, their view of the value of the course to their teaching, and their ability to train other teachers, and (2) course participants are surveyed at the beginning and end of the course to assess any change in their perception of their ability to be WES education resource teachers and their level of improvement in science content understanding.

Participant course satisfaction from end-of-semester evaluations administered during the inaugural 2001-02 academic year was extremely positive. In Fall 2001, 98% of respondents gave the "course as a whole" a rating of "good," the most positive of three possible choices. In Spring 2002, 97% of respondents gave the same highest rating. The most positive response for "science content" was 98% in Fall 2001 and 99% in Spring 2002. The course's "teacher enhancement value" was given the most positive rating by 93% in Fall 2001 and 92% in Spring 2002.

The pedagogical portion of the survey requested participants to assess their ability to meet student needs through WES, use WES to teach science, manage learning using Internet sources of information on water-related topics, and assist colleagues to teach those topics using the Internet. During both Fall and Spring semesters, assessment of individual ability increased 1.4 categories, from "rudimentary" to "adequate/superior" as a consequence of taking WES. The average number of correct responses to science content questions between the beginning and ending surveys increased by 16.8% in Fall 2001 and 11.4% in Spring 2002. In both cases, the magnitude of change is statistically significant at $p = 0.5$.

Participant reports of the number of fellow teachers and students impacted immediately by their individual WES experience averaged 4.6 teachers and 168.2 students in Fall 2001 and 4.1 teachers and 167.2 students in Spring 2002.

5. CONCLUSION

Water in the Earth System is a science content-rich teacher enhancement course that employs a highly motivational teaching approach that promotes inquiry and is adapted for electronic delivery to adult learners. WES is offered nationally but implemented locally via collegial learning teams (LITs) who assist participating teachers in mastering science content, applying appropriate pedagogy, and becoming WES resources teachers in their schools, districts, and communities. Results of surveys administered during the first two semesters of national implementation demonstrate that teachers have benefited substantially from their WES experience. WES is providing them with a wealth of scientifically authentic knowledge and tools that they can use to design inquiry-based lessons for their students. For more information on WES, go to <http://www.ametsoc.org/amsedu/WES>.

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