1.2 WATER IN THE EARTH SYSTEM (WES): MOVING TOWARD NATIONAL IMPLEMENTATION

Ira W. Geer
American Meteorological Society
Washington, DC

David R. Smith,
United States Naval Academy
Annapolis, Maryland

Joseph M. Moran
University of Wisconsin-Green Bay
Green Bay, Wisconsin

Robert S. Weinbeck
SUNY College at Brockport
Brockport, New York

Edward J. Hopkins
University of Wisconsin-Madison
Madison, Wisconsin

1. INTRODUCTION

Water in the Earth System (WES) began in 1999 as an educational initiative of the American Meteorological Society. It is a web-based distance-learning course for precollege teacher enhancement funded by the National Science Foundation. Teachers who successfully complete WES earn three hours of graduate credit from the State University of New York (SUNY) at Brockport and serve as WES resource teachers in their schools and school districts.

WES is modeled after the DataStreme Project, a highly successful program that trains teachers on the use of real-time weather data in the precollege classroom (Weinbeck, *et al.*, 2002). The primary focus of WES is to investigate the flow of water and energy in the global water cycle from an Earth system science perspective. Through a unique paradigm, WES integrates and applies fundamental concepts of meteorology, oceanography, and hydrology in examining mass and energy transfer in the hydrologic cycle. A central theme of WES is society's response to and impact on the global water cycle. As with DataStreme, WES instruction is partially delivered via the Internet, providing teachers and their students with highly motivational experiences in computer-based technology as they access and interpret near-real time environmental data in the classroom.

The principal effort during the first full year (2000) of WES involved instructional materials development and the initial training of leaders of the WES Local Implementation Teams (LITs). Principal instructional resources are a twelve-chapter textbook and a study guide covering a variety of topics on water in the Earth system. The WES study guide contains the first parts of each week's two investigations, while the second parts are written to near-real time environmental conditions and delivered (on Tuesday and Thursday) via the course homepage. An essential component

Corresponding author address: David R. Smith, Oceanography Department, United States Naval Academy, 572M Holloway Road, Annapolis, MD 21402.
Email: drsmith@usna.edu

of the WES instructional model is the LIT, consisting of teachers and scientists who serve as mentors for teachers enrolled in the WES course. Each week, LIT members communicate with the teacher-participants via e-mail, phone, or fax and discuss progress on the investigations.

The following reviews WES activities to date including its national implementation during Fall 2001.

2. MATERIALS DEVELOPMENT

During the initial year of WES, considerable effort was devoted to developing materials. A customized textbook was written, since no suitable commercial textbook was available to meet the needs of the course. The text's 12 chapters correspond to the 12-week duration of the course. In content and organization, the WES text is designed to promote inquiry and provide the learner with the scientific background for the WES investigations that form the centerpiece of the course. Chapter titles are:

Introducing the Earth System
Water's Unique Properties
The Global Water Cycle
Water in the Atmosphere: Humidity and Saturation
Water in the Atmosphere: Clouds and Precipitation
Water in the Lithosphere: Groundwater
Runoff: Rivers, Lakes, and Glaciers
Ocean in the Earth System
Atmosphere-Ocean Interaction
Water in Earth's Climate System
Climate and Ocean-Atmosphere Oscillations
Climate Change and the Water Cycle

To insure that the textbook met standards of both scientific integrity and appropriate pedagogy, drafts of the text were extensively reviewed and field-tested during the WES pilot test (Spring 2001).

WES is guided pedagogically by a teaching approach called Project-Based Science (PBS) that seeks to engage learners in exploring their world by investigating meaningful questions. While PBS informed text organization, WES meshes well with other science pedagogies (e.g., event-driven science). Each chapter of the WES text opens with a *case-in-point*, an authentic real-life problem or issue that highlights or applies one or more of the main concepts of the chapter. This is followed by a *driving question*, a broad-based statement that unifies chapter content and provides a central focus from the onset of the chapter. Next is a content-rich *narrative* that introduces and applies scientific concepts to some aspect of the global water cycle, followed by a set of *conclusions* and a list of *basic understandings* (summarizing the essential ideas covered in that week's investigation). Each chapter also includes an *essay* that addresses in some depth a specific topic that builds on a concept introduced in the narrative.

The WES study guide contains the first part of twice-weekly investigations. The WES homepage delivers the online portions of these investigations. Staff scientists/educators at the AMS Education Program in Washington, DC write the online portions of the investigations to near real-time environmental conditions and post them by noon (Eastern Time) on Tuesday and Thursday. The WES homepage also delivers the *Weekly Water News*, first posted on Monday and updated throughout the week. The *Weekly Water News* includes (1) a list of current events related to water (*Water in the News*) along with links for more in depth coverage, (2) the *Concept of the Week* that explores in some detail a topic related to a central theme of the week's investigations, and (3) *Historical Events*, a chronology of past hydrologic events such as major floods. The WES homepage also

includes a link to *Supplementary Information* on subject matter related to the week's topics. The body of the WES homepage provides links to carefully selected Earth System, Atmospheric, Oceanic (Inland Seas), and Terrestrial Information sites along with extras (e.g., glossaries of terms, maps, educational links, chapter photographs, and WES information).

3. WES LIT TRAINING

Central to all AMS education programs is the direct involvement of classroom teachers (Geer *et al.*, 1999). As in the DataStreme Project, teachers who have participated in prior AMS education programs (e.g., Project ATMOSPHERE, the Maury Project) assist in the training of WES participants through membership on local implementation teams. These teacher-trainers must first undergo their own training program to acquire the necessary background in WES organization, pedagogy, and science content. Thirty-five teachers who are alumni of either the Project ATMOSPHERE/ DataStreme programs or the Maury Project were selected to serve as LIT leaders. In addition 35 other teachers were chosen to serve as LIT members. In most instances, the LIT leader and the LIT member were paired to complement each other's skills and backgrounds (e.g., Project ATMOSPHERE/ DataStreme teacher paired with a Maury Project teacher). A professional scientist (e.g., meteorologist, hydrologist) or college professor completed the typical WES LIT.

During the summer of 2000, WES LIT leaders attended a 10-day training program at Annapolis, MD (Geer *et al.*, 2001). They heard lectures on most facets of WES science content and participated in demonstrations and investigations. The next phase of training for the WES LIT leaders and members was participation in the pilot testing of the WES distance-learning course during the Spring Semester of 2001. Each member of the 35 LITs took the WES course following the same format as planned for teachers who will be taking the course when nationally implemented. This experience enabled the LIT members to (1) observe the course from the perspective of potential teacher-participants, (2) become familiar with the logistics and various components of the course, and (3) constructively critique the course. The pilot yielded numerous suggestions for revision of WES materials. Those revisions were undertaken during the Spring and Summer of 2001.

A second training program for WES LIT leaders was held on 1-5 July 2001 and hosted by the Department of Atmospheric and Oceanic Sciences at the University of Wisconsin-Madison. The program consisted of lectures on WES topics by scientists from UW-Madison and other institutions, laboratory demonstrations, group discussions, and a field trip. Lectures included:

- "Ground Water: Uncovering a Hidden Resource," Jean Bahr, UW-Madison
- "Climate Change and the Global Water Cycle," Michael Coe, UW-Madison
- "GIS and Water Resources," James Brey, UW-Fox Valley
- "Great Lakes Research," Joseph Niebauer, UW-Madison
- "Hydrology and the Human Impact," Jeffrey Clark, Lawrence University
- "National Centers for Environmental Prediction," Louis Uccellini, NCEP
- "Acts of God, Nature, and Man," William Hooke, AMS

The field trip led by J. Brey, E. Hopkins, and J. Moran surveyed Wisconsin's Ice Age legacy and included stops at a hydroelectric power plant on the Wisconsin River (operated by the Wisconsin Power and Light Company) and geological points of interest including Parfrey's Glen and Devil's Lake State Park in Wisconsin.

In addition to content-based instruction, a significant portion of the Madison meeting was devoted to discussing individual response to the WES pilot. Discussion focused on the quality and effectiveness of instructional materials and mode of delivery. While numerous constructive suggestions were offered, the group's consensus was that WES learning materials are of high quality and that the course would successfully achieve its learning objectives.

4. NATIONAL IMPLEMENTATION

National implementation of the WES program began in the Fall of 2001. Each of the 35 WES LITs provided instruction for an average of 8 teachers. Twice-weekly investigations of water in the Earth system were delivered via the Internet to about 280 teachers in 32 states. This is the first of at least six semester offerings of the WES course (through Spring 2004). A total of over 1600 teachers are expected to receive WES training. By the time this paper is presented (January 2002), we should have feedback on the initial course offering. That feedback will inform future revision of course learning materials.

4. CONCLUSION

Water in the Earth System is aligned with the *National Science Education Standards* and models a science content-rich and highly motivational teaching approach adapted for electronic delivery to adult learners. The goal of WES is to provide professional teachers with a wealth of scientifically authentic knowledge and tools that they can use to design inquiry-based lessons.

The WES Program is now fully implemented. Final versions of WES learning materials have been produced, reviewed, pilot tested and distributed for national implementation (Fall 2001). The WES website is fully operationally, delivering instructional investigations and supporting environmental data to participating teachers. Thirty-five WES LITs in 32 states will continue to provide valuable feedback as the course is conducted over the next several years.

For additional information on WES, go to http://www.ametsoc.org/amsedu/WES

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