METEOROLOGY AND CLIMATOLOGY: ON-LINE WEATHER STUDIES

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Abstract

Through the Virginia Earth Science Collaborative (VESC), a partnership of nine institutes of higher education, non-profit organizations, and eighty-three school divisions, a 3-credit, graduate-level meteorology course was offered six times between Spring 2006 and Fall 2007. The course, entitled *Meteorology*, was offered at three locations (Richmond, Abingdon, and Harrisonburg), and a local instructor facilitated each section. Funding for the course development, instructor stipends, and participant expenses (including travel, meals, and tuition) was provided through a competitive Mathematics and Science Partnership (MSP) grant funded through the federal No Child Left Behind legislation of 2001. The framework of the course was the American Meteorological Society's *Online Weather Studies* program, which provides meteorological content and laboratory investigations, and relies heavily on the use of Internet-accessed, real-time weather data to teach meteorological topics in a distance learning format. The 115 teacher participants were required to complete text readings and written assignments, conduct laboratory investigations, design projects using real-time meteorological data, complete exams, and attend three face-to-face meetings. For the purpose of the VESC grant evaluation, pre-test and post-test data were collected on 110 of the participants which indicated an average 14.7% increase in participants' content knowledge and use of real-time meteorological products (weather maps, satellite images, station models, etc.) in their instructional delivery.

Introduction

In order to achieve the Virginia Earth Science Collaborative's (VESC) goal of increasing the number of certified teachers with earth science endorsements in the state, a 3-credit, graduate-level course, *Meteorology*, was developed and implemented six times at three statewide locations by local instructors (see Table 1). Teachers participating in the VESC enrolled in the course at a location and time most convenient for their schedule.

Tuition was paid by the VESC grant, in addition to the travel expenses of teachers living more than ninety minutes from the course location.

Table 1
VESC *Meteorology* Course Offerings

Date	Location	Academic Credit	Instructor(s)
Spring 2006	Mathematics & Science Center Richmond, Virginia	VCU*	Ms. Beth Jewell Mrs. Jo Ann Mulvany
Spring-Summer 2006	James Madison University Harrisonburg, Virginia	JMU	Eric J. Pyle, Ph.D. Elizabeth Alford, M.S.
Summer 2006	University of Virginia Southwest Center Abingdon, Virginia	UVA	Michael Bentley, Ed.D.
Fall 2006	Mathematics & Science Center Richmond, Virginia	VCU	Mrs. Jo Ann Mulvany
Spring 2007	James Madison University Harrisonburg, Virginia	JMU	Eric J. Pyle, Ph.D. Elizabeth Alford, M.S.
Fall 2007	MathScience Innovation Center** Richmond, Virginia	VCU	Mrs. Jo Ann Mulvany

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** Formerly the "Mathematics & Science Center."

Course Development

Juanita J. Matkins, Ed.D. of the College of William & Mary served as the lead instructor for the development of *Meteorology*. Recognizing that different instructors with varying degrees of experience would be teaching *Meteorology* at three separate locations, it was important to provide a course framework that would ensure content continuity. The American Meteorological Society's (AMS) *Online Weather Studies* program (2005) was selected as the backbone of the VESC's *Meteorology* [1]. This AMS program was designed for use by experienced meteorology instructors, as well as those with no formal training in the atmospheric sciences. The AMS *Online Weather Studies* (*OWS*) program can be used to offer a twelve- or fifteen-week distance learning course, and is built around studying weather as it happens by using current meteorological data delivered via the Internet. Archived data is used for studying historical weather events. Archived data of previous semesters are available for those using the AMS

materials during a summer or interim semester. When using the *OWS* program, the AMS sells the textbook and laboratory manual as a package [2-3]. Access to the course website is through a login and password provided for a licensure fee.

Once it was decided to use the *OWS* program as the framework of the VESC *Meteorology* offering, the instructors collaborated to adapt the AMS coursework for use in the VESC offering. It was decided that there would be three face-to-face meetings of approximately six hours each over the time period of the course. All instructors required the development of an investigative, meteorology-based lesson plan. For the purpose of uniform grant assessment data, all instructors administered the same pre-test/post-test (see Table 4). Once these commonalities were established, each instructor incorporated additional requirements to his/her syllabus.

Course Description and Objectives

Each instructor held three face-to-face meetings spaced evenly over the time frame of their course. In between these meetings, participants were required to work independently using text materials and Internet-accessed, real-time and near real-time data. Each course featured applications of experimental design to meteorology. The content topics of all VESC *Meteorology* offerings related to the *Science Standards of Learning* in the "Earth Science" section (ES 3, 9, 11, 12, 13) and Grade Six (6.3, 6.6) [4].

All of the *Meteorology* course offerings included the following major objectives:

- Develop understanding of atmospheric dynamics;
- Increase proficiency in accessing and interpreting real-time and archived weather data for instructional use; and,
- Develop *SOL* meteorology lessons and investigations incorporating real-time weather data.

Demographics of Participants

The *Meteorology* courses were completed by a total of 115 teachers representing forty Virginia county and city school divisions extending from Russell and Washington counties in the southwest, to Frederick and Fairfax in the north, to Westmoreland and Lancaster counties in the east, and to Pittsylvania and Mecklenburg in the south. The highest concentration came from the central Virginia area. Each of the teachers held a license in one or more of the following areas: biology, chemistry, earth science, middle school science, general science, middle school math, special education, elementary education, agriculture technology, geography, and physical

education. Three had provisional certificates and two had no license. The teachers were currently teaching in one or more of the following disciplines: high school science, middle school science, middle school mathematics, special education, and/or geography.

Materials Used in the Course

The AMS *OWS* program includes a textbook, the laboratory *Investigations Manual* and access to the *Online Weather Studies* component of the American Meteorological Society's website [1-3]. Users of the *OWS* program pay a licensure fee which gives participants access to the password-protected website for the course duration [1]. The hardcover textbook, *Weather Studies: Introduction to Atmospheric Science*, was written by Dr. Joseph M. Moran, Associate Director of the AMS Education Program and of the University of Wisconsin - Green Bay [2]. Each of its fifteen chapters cover a major meteorological topic. This includes: weather tracking, the origin, composition and structure of the atmosphere, solar and terrestrial radiation, atmospheric heat, temperature and circulation, air pressure, humidity, saturation, stability, clouds, precipitation, radar planetary circulation, middle latitude weather systems, thunderstorms, tornadoes, tropical weather systems, the analysis of weather events using real-time satellite imagery (visible, infrared, water vapor), weather forecasting, light and sound in the atmosphere, and climate and climate change.

The laboratory *Investigations Manual* contains a set of student learning investigations and is coordinated with the textbook chapters [3]. Each investigation (two per week) is complete in the *Manual*, but may be reinforced by Current Weather Studies accessed via the program website. Investigations lead the student through analysis and interpretation of real-world weather. The *OWS* program website includes the delivery of Current Weather Studies which reinforce key concepts in the textbook and printed *Investigations Manual* by using current weather data.

Description of Face-to-Face Meetings

Each of the three face-to-face meetings was held at the course site on the advertised dates from 10 A.M. to 3 P.M. The instructors each planned the agenda for their classes based upon the needs of the participants and the available resources. Commonalities and variations are shown in Table 2.

Table 2
Synopsis of Face-to-Face Meeting Agendas

Face-to-Face Meetings	M. Bentley—University of Virginia Southwest Center	B. Jewell and J. Mulvany—MathScience Innovation Center
One	*Introductions •Pre-Test •Syllabus •Investigations—1A and 2B •Content discussion—structure of the atmosphere and climatology	•Introductions •Pre-Test •Syllabus •Investigations—1A and 1B •Content discussions—weather systems
Two	•Investigations—Atmospheric moisture •Content discussions—NASA cloud data project, S'COOL, Globe, history of meteorology	•Investigations—Atmospheric moisture •Content discussions—Atmospheric stability, instability •Midterm exam
Three	•Content discussions—climate, climate change, and climate dissidents •Video—*An Inconvenient Truth* •Project presentations •Post-Test/exam	•Investigations—Hurricanes •Project presentations •Content discussions of Chapters 7-12 •Post-Test •Final exam

Description of Laboratory Experiences

Weather data contained in the laboratory *Investigations Manual* and the real-time or archived data accessed from the *Online Weather Studies* website provided the basis for most of the laboratory investigations. Laboratory *Investigation Manual* topics are shown in Table 3, and a complete archived sample of the Activities 1A and 1B can be found on-line [5].

When users of the *OWS* materials conduct their course in the same time frame as the AMS program, the accessed data is in near real time. Investigations with real-time data are posted Mondays (Chapter Investigation A) and Wednesdays (Chapter Investigation B) for a twelve-week college semester. The investigations are then archived for users operating on varying schedules. All of the VESC's *Meteorology* classes operated on semesters that varied from the AMS schedule, and therefore relied on the most recent archived data for use in the on-line investigations component. In addition to the *OWS* investigations, each instructor provided additional hands-on activities at the three face-to-face meetings.

Table 3

***Online Weather Studies Investigations* Listing**

1A: Air Pressure and Wind	1B: Surface Air Pressure Patterns
2A: Surface Weather Maps	2B: The Atmosphere in the Vertical
3A: Weather Satellite Imagery	3B: Sunlight Throughout the Year
4A: Temperature and Air Mass Advection	4B: Heating Degree-Days and Wind Chill
5A: Air Pressure Change	5B: Air Pressure in the Vertical
6A: Clouds, Temperature, and Air Pressure	6B: Rising and Sinking Air
7A: Precipitation Patterns	7B: Doppler Radar
8A: Surface Weather Maps and Forces	8B: Upper-Air Weather Maps
9A: Westerlies and the Jet Stream	9B: El Niño!
10A: The Extra-Tropical Cyclone	10B: Extra-Tropical Cyclone Track Weather
11A: Thunderstorms	11B: Tornadoes
12A: Hurricanes	12B: Hurricane Wind Speeds and Pressure Changes
13A: Weather Instruments and Observations	13B: Weather Forecasts
14A: Optical Phenomena	14B: Atmospheric Refraction
15A: Visualizing Climate	15B: Local Climatic Data

Role of Instructor During the Course

Primarily a distance learning course, communications between instructor and participants were a key factor. These communications came in the form of individual and group e-mails, phone calls, postings and chats using *Blackboard*®, and assessments via *WebSurveyor*®. For their three course meetings, instructors planned and delivered the instructional agenda. This included lectures, *PowerPoint* presentations, handouts, laboratory investigations, discussions, and exams. In between the meetings and at times established by each instructor, participants electronically submitted chapter progress and critical thinking questions, laboratory investigations, and on-line investigations answers to their instructor. Subsequently, the instructors graded the work for completion and accuracy, and electronic feedback was provided to participants.

Methods of Evaluating Participants

At the initial course meeting, participants were administered a pre-test developed by Dr. Juanita Jo Matkins (College of William & Mary). This pre-test consisted of a combination of multiple-choice and discussion questions addressing meteorology content, instructional strategies, and the use of current on-line weather data. Representative items from the pre-/post-test are

shown in Table 4. Participants were told that the scores on the pre-test would not be used to determine their grade, but would be scored for grant evaluation and, at most, would configure into their grade as a component of the participation grade. At the final course meeting, the same instrument was administered as the post-test and counted as a part of the participation grade or the exam grade at the discretion of the instructor. Dr. Matkins and Dr. George Bass (External Evaluator, Associate Professor, College of William & Mary) scored the pre-tests and post-tests and did the subsequent data analysis.

Table 4
Sample Pre-/Post-Test Items for VESC's *Meteorology*

General (one point each)	How would you gauge your current ability to: 1) use weather-related content (meteorology) to meet your needs in daily life? Minimal Rudimentary Adequate Superior Exemplary 3) access current weather data and information from the Internet to learn science? Minimal Rudimentary Adequate Superior Exemplary
Content (One point each)	7) At Northern Hemisphere, mid-latitude locations, assuming clear skies, the daily amounts of incoming solar radiation in late September are _____ the amounts at the same location in late March. a) less than b) about equal to c) greater than 13) Immediately after a warm front has passed your location, you usually can expect precipitation to _____ and temperatures to _____. a) begin .. drop. b) end .. rise. c) end .. drop. d) begin .. rise.
Discussion (four points each)	23) Mountaintops are closer to the Sun than lowlands, and yet mountaintops are colder than lowlands. Why? 25) The Virginia *Standards of Learning*, ES.1 states, "The student will plan and conduct investigations in which technologies, including computers, probeware, and global positioning systems (GPS), are used to collect, analyze, and report data and to demonstrate concepts and simulate experimental conditions; scales, diagrams, maps, charts, graphs, tables, and profiles are constructed and interpreted; and, a scientific viewpoint is constructed and defended (the nature of science)." [6] Describe how you could use available on-line weather data in lessons culminating in student investigations of meteorology topics.

Individually, the course instructors established the guidelines for determining the participants' academic grades in their course by weighting and averaging the required assignments of their syllabus. Variations in the syllabi are shown in Table 5.

Table 5
Evaluation Components

M. Bentley	B. Jewell and J. Mulvany	E. Pyle
25%=Final exam	30%=Average of midterm and final exams	15%=Scoring of post-test in lieu of a final exam
37.5%=Completion of chapter questions, laboratory investigations, on-line investigations, weekly postings to Discussion Board and participation in on-line class and chat meetings	40%=Completion and accuracy of chapter questions, laboratory investigations and on-line investigations	35%=Completeness and accuracy of laboratory investigations and on-line investigations
12.5%=Creation of *WebQuest* Activity	20%=Lesson plan development	20%=On-line quizzes submitted via *Websurveyor* every 2-3 weeks
25%=Completion of meteorology project	10%=Attendance	20%=Project/Investigative Plan
		10%=Attendance

Performance of Participants

The academic grades submitted by the instructors to their respective registrars were mostly A's and B's with an occasional C (based on a 10-point grading scale) or incomplete. Most participants found that instructor expectations were reasonable, the workload manageable, and the *OWS* materials challenging, but written at a level that developed meteorological understanding without extensive scientific background. Participants who encountered difficulties generally did so due to time management challenges.

For participants who completed both the pre- and post-tests, the analysis of data provided by Dr. George Bass, External Evaluator, is shown in Table 6. The combined data analysis provided by Dr. Bass showed a mean increase of 14.7% in the *Meteorology* sections. In his report, Dr. Bass identified a weighting bias toward the short-answer questions, as each short-

answer question counted four points, whereas the multiple-choice answers had an assigned one-point value. Dr. Bass indicated that the participants performed poorly on the three short-answer questions which contributed to the small mean gain. A possible explanation for weak participant performance on the three short-answer questions resides in the post-test arrangement. The post-test was given as one of the last agenda items at the final course meeting. As indicated previously, the instructions given by Dr. Matkins stated that the data would not factor into the academic grade, but as a participation grade at the instructors' discretion. The incentive to invest time in writing quality answers was low.

Table 6

Summary of Pre-/Post-Test Achievement Data of Participants in VESC's *Meteorology*

Meteorology Combined Data	Number of Participants	Mean Pre-Test (%)	Mean Post-Test (%)	Difference (%)
	110	53.7	68.6	14.9

Lessons Learned

Participants from the MathScience Innovation Center-VCU Fall 2006 class completed a course evaluation for the MathScience Innovation Center (MSiC). Their responses indicated that 85.6% agreed or strongly agreed that the course had increased their academic understanding of the concepts. With respect to the instructional materials, 85.1% agreed or strongly agreed that they were useful, and 88.5 % agreed or strongly agreed that they would integrate the ideas into their teaching. Favorable comments were made about the distance learning aspect of the course. Participants liked being able to work at home when it was convenient for them. Several commented that the labs were excellent and had good hands-on practice with both the *Investigations Manual* and the on-line materials as guides. They indicated that the information was easy to use, current, and valuable for teacher knowledge and resources. Most found the coursework challenging, but appropriate for a graduate-level course.

Several participants, however, found the content to be intense, and indicated that they would have enjoyed weekly face-to-face interactions with an instructor. They indicated that they spent copious amounts of time figuring out concepts that could have been quickly explained by an instructor.

From the instructors' perspective, the AMS *Online Weather Studies* program and materials gave needed continuity to the meteorological instruction. Though each instructor approached the topics differently, the use of the *OWS* materials provided a uniform backbone for the coursework, and required very little modification to the needs of VESC's *Meteorology*. The materials were well written for graduate-level students with minimal meteorological content knowledge. The website operated dependably, and the investigations provided the participants with numerous examples in the use of real-time or near real-time data as an instructional delivery tool. In addition, the distance learning approach greatly diminishes schedule interruptions caused by conference travel, vacations, sickness, and family emergencies. With Internet connectivity, an instructor can manage their course responsibilities efficiently.

The University of Virginia Southwest Center instructor in Abingdon, Virginia used *Blackboard*®, and found it to have both strengths and weaknesses. It did allow for content reflection, feedback to questions, and a method for the exchange of materials. However, "bugs" in the system—inability to copy/paste URL's, ability of participants to see or not see URL's—diminished its effectiveness.

Recommendations

Continued use of the AMS *OWS* is highly recommended. The purchase of WeatherCyclers (weather system tracking and forecasting educational devices) and a NOAA weather radio for each participant is suggested. These materials could be distributed at the final meeting to those who had successfully completed the course.

The addition of another face-to-face meeting would alleviate the concerns of those who indicated difficulty with learning independently. This additional meeting (between the first and second meetings) would provide an opportunity to discuss several of the more challenging topics (specific heat calculations and adiabatic lapse rates), to preview upcoming topics of difficulty (stability and instability), and to provide exam review and data interpretation practice.

Incorporating the post-test questions into the final exam and having the post-test data uniformly impact the final grade calculation of all participants should be considered for future coursework. This modification would increase the likelihood that the post-test data would accurately reflect the gain in meteorological knowledge and the use of Internet accessed data for the development of instructional materials. The motivation for writing strong, short-answer questions would be increased if the outcome affected the participants' final grade.

Conclusion

Overall, participants reacted positively to the course materials, the course format, and the paradigm of teaching weather using current weather data. Submersion in meteorological content and Internet-accessed weather products (air pressure data, temperature data, climatograms, etc.) resulted in an increased confidence in participants' abilities to teach meteorology and to adequately prepare their students for *SOL* meteorology questions. While participant access to the *Online Weather Studies* website ended at the conclusion of the course, those who wanted to continue to develop and use real-time weather data in their instruction were able to access the same products used in the course laboratory *Investigations Manual* at the American Meteorological Society's "DataStreme Atmosphere" component of the website [7]. Participants indicated an interest in having additional courses delivered using the format of the AMS *Online Weather Studies* program. ■

References

[1] *Online Weather Studies*, American Meteorological Society; Internet: http://www.ametsoc.org/amsedu/online/index.html.

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[7] "DataStreme Atmosphere,"American Meteorological Society; Internet: www.ametsoc.org/amsedu/dstreme/.