Integrating New Technologies in the Earth Sciences: A Web-Based Course

By

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Abstract

As part of the Virginia Earth Science Collaborative, a special course on *Integrating New Technologies in the Earth Sciences* (3-graduate credits) was developed and delivered to 35 teachers from across the Commonwealth. Five major technologies were addressed: remote sensing and image processing, real-time and real-world data, computer simulations and 3D modeling, global positioning systems and geographic information systems, and graphing calculators and probes. The course was a blend of face-to-face and web instruction through *Moodle*, a web-based instructional system used by the MathScience Innovation Center (formerly the Mathematics & Science Center). Participants met for two face-to-face sessions on Saturday and completed the remaining instruction through *Moodle*. An initial course was offered in the fall of 2005 and a second course in the spring of 2006. On a pre-post Likert-type survey, participants showed positive increases in their conceptual understanding and skills in the newer technologies, with the strongest gains occurring in use of global positioning systems and geographic information systems and use of real-time and real-world data. Participants identified the modular format of the class, volume and quality of information and resources provided, the interaction with other participants, and the instructor's competence as major strengths. As in most web-based classes, the dropout rate was higher than normal, with participants either performing very well (A's and B's) or making F's because they did not complete assignments. Recommendations for improvement included screening participants more closely for suitability to a web course and having more intense coursework and deadlines earlier in the course to ensure that the individual had a high probability of success (or could withdraw before the deadline). Some participants cited a need for increased interaction through additional face-to-face sessions or more active web-chats and discussions. Overall, the course was a successful pilot and illustrated how a blended face-to-face and web class can be used to meet a statewide audience and to engage participants in active inquiry.

The Need

On a Teacher Survey administered prior to development of the MSP Proposal, *Virginia Earth Science Collaborative: Developing Highly Qualified Teachers*, 146 teachers requested a course on effective strategies including "good" hands-on labs (not paper-pencil worksheets), effective computer software and simulations, and use of global positioning systems, geographic information systems, imaging software, and calculator-based labs. A recurring theme was materials that helped students see the relevance of Earth Science in their community.

To meet this need, *Integrating New Technologies in the Earth Sciences*, was developed and piloted in the fall of 2005 in the Richmond area; development included a web-based collaborative student project relevant to Virginia. Drew Keller, an educator at the MathScience Innovation Center, led development of this course, which built upon the Center's expertise in GIS, GPS and web-based instruction. Jackie McDonough, Adjunct Professor at Virginia Commonwealth University, six outstanding earth science educators, and three members of the Virginia Department of Mineral Resources assisted with course design. The course was a blend of face-to-face and web instruction through *Moodle*, a web-based instructional system used by the Center. The 3-credit graduate course was offered through Virginia Commonwealth University's School of Education. The course was offered a second time in the spring of 2006.

Population

A total of 35 teachers participated in the course, 21 in the fall of 2005 and 14 in the spring of 2006. On a *Teacher Survey* administered prior to admission in any Virginia Earth Science Collaborative course, participants identified themselves in the following categories:

- Secondary science teacher completing or adding an Earth Science endorsement (43%);
- Middle school or special education teacher completing 18 college credits toward an Earth Science endorsement (6%);
- Endorsed earth science teacher taking the course to strengthen their background (31%);
- Other reason – technology specialist strengthening their background in newer technologies and use of Moodle technology for course delivery (20%).

Because the course was designed for endorsed earth science teachers, the large percentage of teachers who had not completed the endorsement who enrolled was surprising. However, these teachers indicated that they had been introduced to the technologies in other VESC courses and wanted to immediately gain the skills needed to use them with their students. Technology specialists with a science background also showed a strong interest in the course.

Course Materials

The overall goal of the course was to engage participants in the technologies used by Earth Science professionals and to increase their understanding of concepts through real-world examples. Major topics included remote sensing and image processing, real-time and real-world data, computer simulations and 3-D modeling, GPS and GIS, graphing calculator-based labs, and web-based collaborative projects. The online distance learning component used a web-based content management system, *Moodle*, hosted by the Center. Drew Keller, Educator at the Center, taught the course with Jacqueline T. McDonnough, Assistant Professor at Virginia Commonwealth University, providing some assistance. Three graduate credits were provided by Virginia Commonwealth University's School of Education.

Course Objectives. The course was divided into five modules, with specific objectives developed for each of the major topics:

Remote Sensing & Image Processing

- List the different types of sensors used to study landform structures, predict weather and map land cover.
- Compare aerial photography and satellite images.
- State how science explains and predicts the interactions and dynamics of complex Earth systems using remote sensing data.
- Apply techniques of enhancement and quantification of digital imagery acquired by remote sensing and other methods.
- Possess the skills and knowledge to successfully integrate remote sensing and image processing into classroom instruction.

Real-time and Real-world Data

- Describe difference between continuous and discrete data
- Identify and convert the time and date that real-time data are recorded to local time.
- Possess the skills and knowledge to successfully integrate real-time and real-world data into classroom instruction

Computer Simulations & 3D Modeling

- Load a computer software application or plug-in into a browser
- Read directions for use of application
- Use application that makes use of 3-D modeling and or a simulation
- Possess the skills and knowledge to successfully integrate computer simulations and 3D modeling into classroom instruction

Global Positioning Systems & Geographic Information Systems

- List 3 components of GPS
- Use a GPS unit
- Perform basic GPS functions: log waypoints, record speed, list satellites, download waypoints and track log into computer
- Define GIS
- Use several GIS software applications
- Build a map with several layers/themes
- Identify several applications of GIS software
- Possess the skills and knowledge to successfully integrate Global Positioning Systems & Geographic Information Systems into classroom instruction

Graphing Calculators & Probes

- Use a CBL with probeware and graphing calculator together to collect data
- Analyze graphs of measurements and data
- Interpret results of experiments
- Possess the skills and knowledge to successfully integrate the use of graphing calculators and probes to collect data, graph measurements and analyze results in the classroom

Collaborative Project

- Collect and post data via a website
- Operate a digital camera
- Upload images from a digital camera to a server via the world wide web
- Operate GPS unit to record location where an image was recorded
- Record digital images of physiographic features unique to your area of Virginia:
  - Outcrops
  - Drainage Terraces
  - Karst topography
  - Scarps
  - Rock Type

Materials. Either the participant or the participant's school was responsible for providing: a) global positioning system, GPS receiver, b) digital camera with picture quality of 1 Megapixel or greater, c) TI Graphing Calculator (except TI-82 or TI-85), and d) computer with Windows 98/2000XP or Mac OS 10.3+. If participants could not obtain a GPS receiver or digital camera, the materials were loaned by the Center for the duration of the course. In addition, the each participant received:

- Lab Book 'Earth Science with Calculators' by Vernier Software & Technology containing 33 hands-on graphing calculator based labs using LabPro or the CBL 2 Interface and Vernier sensors ($45 value);
- 3 (CD-ROM) Easy-to-use Interactive 3D software applications licenses to help students learn difficult concepts in Earth Science and Astronomy ($165 value);
- CBL 2 – Data collection tool from TI; more then 50 sensors can be connect to the CBL 2($166 value);
- 2 Vernier sensors: Magnetic Field Sensor and Temperature probe sensor ($83 value).

Course Calendar/Schedule for Section 1.

Distance learning began September 26th, 2005 and ended January 23rd, 2006

Two **mandatory** face to face meeting took place on:

October 8th, 2005 at the Mathematics and Science Center from 9:00am to 4:00pm

December 3rd, 2005 at the Mathematics and Science Center from 9:00am to 4:00pm

Module/Topic	Suggested Due Dates (* Mandatory Due Date)
Introduction	* October 7th (Required)
Remote Sensing & Image Processing	October 23rd
GPS & GIS	November 10th
Computer Simulations & 3D Modeling	November 25th
Real-Time and Real World Data	December 20th
Graphing Calculators & Probes Lesson	January 15th
Collaborative Project	* January 23rd (Required)

Grading

There were 500 points possible in the course. The table below lists the lessons and project, and the points for each related lesson and project. Points were awarded based on a grading rubric. Rubrics were provided in connection with each module.

Module/Topic	Points
Introduction	15 points
Remote Sensing & Image Processing	75 points
GPS & GIS	75 points
Computer Simulations & 3D Modeling	75 points
Real-Time and Real World Data	75 points
Graphing Calculators & Probes Lesson	75 points
Collaborative Project	110 points

The following scale was used to determine final grades:

90 - 100	percent	450-500	points	A
80 - 89	percent	400-449	points	B
70 - 79	percent	350-399	points	C
60 - 69	percent	300-349	points	D

Modifications for Section 2 . TBD

Impact

Section 1. For this combination web-based and face-to-face course, a pre-post questionnaire was administered in which participants rated their expertise in five content domains as well as skills and resource availability. Participants selected from five choices: none (0), little (1), some (2), much (3) and expert (4). In addition, participants were asked to respond to several open-ended questions at the beginning and end of the course.

Before the course, participants responded to the question, “What are your reasons for taking this course?” Major reasons were endorsement, re-certification and more effective use of technology in the classroom, especially where schools had increased access to computers. Participants also responded to the question, “What skills do you want to have at the end of the course?” Although most participants cited a general increase in ability to use technologies and to integrate them into instruction, others cited specific technologies of interest. GPS & GIS and use of digital cameras were cited most frequently. Fewer participants cited specific interests in graphing calculators/probes, remote sensing, 3D imaging, and real-time data. When asked: “What other information would you like the instructor to know?” many participants stated that they were new to technology and “out of the loop” when it came to teaching earth science using technology.

As shown in Table I, participants generally ranked themselves as having “little” content knowledge at the beginning of the course and “some” content knowledge at the end of the course. Content knowledge increases were greatest in the areas of remote sensing and imaging, computer simulations and 3D modeling, and global positioning and geographic information systems. Less change was shown in the area of graphing calculators/probes, where many schools have done in-service, and in real-time and real-world data, where many earth science teachers already accessed meteorology and oceanographic data.

Table I: Participants’ Perceptions of Pre-Post Content Expertise

Question: Please rate your expertise in the content area of ______.	Average Pre- Course Rating	Average Post-Course Rating	Average Difference Pre-Post
Remote sensing and Image Processing	1.05	2.23	1.18
Real-Time and Real-World Data	1.38	2.15	0.77
Computer Simulations and 3D Modeling	1.00	2.15	1.15
Global Positioning Systems and Geographic Information Systems	1.14	2.38	1.24
Graphing Calculators and Probes	1.24	1.92	0.68
AVERAGE	**1.16**	**2.17**	**1.01**

Participants were also requested to compare their pre-post skills regarding resource availability. Generally, before the course participants rated resource availability as “little to some;” whereas, after the course they rated availability as “some to much.” The greatest change in resource availability was shown for GPS and GIS because participants received a GPS unit and access to the MSiC’s web-based GIS system as part of the course (see Table II).

Table II: Participants' Perceptions of Resources Availability

Question: Please rate the **resources** available to you in the area of ______.	Average Pre- Course Rating	Average Post-Course Rating	Average Difference Pre-Post
Remote Sensing and Image Processing	1.67	2.67	1.00
Real-Time and Real-World Data	1.80	2.80	1.00
Computer Simulations and 3D Modeling	1.80	2.73	0.93
Global Positioning Systems and Geographic Information Systems	1.87	2.93	1.06
Graphing Calculators and Probes	2.00	2.73	0.73
AVERAGE	**1.83**	**2.77**	**0.94**

With respect to skills in using resources, participants showed gains ranging from 1.06 to 1.27. Initially, most participants rated their skills as "little" to "some"; whereas, after the course skills levels were rated as "some" to "much." Skill increase was greatest in the area of GPS and GIS followed closely by use of real-time and real-world data (see Table III).

Table III: Participants' Perceptions of Skill in Using Resources

Question: Please rate your skills in using resources available to you in the area of ______.	Average Pre- Course Rating	Average Post-Course Rating	Average Difference Pre-Post
Remote Sensing and Image Processing	1.40	2.67	1.27
Real-Time and Real-World Data	1.60	2.80	1.20
Computer Simulations and 3D Modeling	1.67	2.73	1.06
Global Positioning Systems and Geographic Information Systems	1.60	2.87	1.27
Graphing Calculators and Probes	1.47	2.53	1.06
AVERAGE	**1.55**	**2.72**	**1.17**

After course completion, participants responded to the question: "What did you enjoy most about this course?" Repeatedly, participants mentioned the range of resources and websites, learning about technology that they did not realize was available, interacting with colleagues, and the way that the course was set up. This quote from a teacher summarizes points made by many in the class:

> *"I enjoyed the format – we were introduced to sites where we could explore the technology, find the lesson plans, and have a wealth of resources to which to go back. This was followed by an activity (or activities) in which we actually applied the technology – just as we would want to do with our students. At the end of each module we also contributed to a forum discussing our ideas of how we would use this particular technology in our classroom. It was very well done. "*

Participants were also asked to identify the strong and weak points of the class. Major strengths were the modular format of the class, volume and quality of information and resources provided, interaction with other participants, and the instructor's competence including knowledge, patience, and promptness of replies. After participating and reflecting upon use of materials with students, one teacher's comments are indicative of many:

> *"This course had an abundant source of information about the real world's technology today - some of which I had not experience(d) before. Many of the exercises required lots of reading which I believe will be a deterrent to the students. I am so grateful to have had this opportunity. I feel refreshed with ideas and awakened from the routine. This course has given me many ideas for grants. Thank you so very much. "*

Section 2. In the late spring and early summer of 2006, the course was offered for a second time with 14 people participating. Again, participants completed a pre- and post-survey in which they ranked their competencies on a 5-point scale with 0 = none, 1 = little, 2 = some, 3= much and 4= expert. Unfortunately, the electronic data for the pre-test could not be found in the Moodle System (instructor had moved to Texas) and post-data from only six participants was located. Data on these six participants' rating of "expertise" are presented in Table IV .

Table IV: Participants' Post-Course Perceptions of Expertise

Expertise	Percentage					Weighted Average
	None (0)	Little (1)	Some (2)	Much (3)	Expert (4)	
Remote sensing & image processing		16.7	33.3	50.0		2.33
Computer simulations & 3-D modeling		16.7	16.7	66.7		2.50
Geographic Information Systems & Global Positioning		16.7	83.3	0.0		1.83
Real-Time & Real-World Data		16.7	33.3	50.0		2.33
Computers & Probeware		16.7	33.3	33.3	16.7	2.50
Weighted Average for Subcategory						**2.29**

The post-course average of 2.29 was slightly higher than the value for the 2005 course, e.g. 2.17. Generally, participants perceived that they had "some" to "much" expertise in each of the fields. In the 2005 class, participants began with "little" expertise and grew by approximately 1 point. Given the post-course average, one could hypothesize that entry level skills were similar in both classes. Regarding resource availability, participants' perceptions are summarized in Table V.

Table V: Participants' Post-Course Perceptions of Resource Availability

Awareness of Resources Available	Percentage					Weighted Average
	None (0)	Little (1)	Some (2)	Much (3)	Expert (4)	
Remote sensing & image processing			33.3	66.7		2.67
Computer simulations & 3-D modeling			33.3	66.7		2.67
Geographic Information Systems & Global Positioning			16.7	83.3		2.83
Real-Time & Real-World Data			16.7	83.3		2.83
Computers & Probeware			16.7	66.7	16.7	3.00
Weighted Average for Subcategory						**2.80**

The mean for awareness of resources was essentially the same for 2006 and 2007 participants, e.g. 2.8 vs 2.73. Generally participants perceived "some" to "much" awareness of resources. Awareness of probeware was greater in the 2006 class; however, data are not directly comparable for calculator-based probes were used in 2005 and computer-based probes in 2006.

Participants' post-course ratings of their ability to implement instructional strategies in targeted technology areas are summarized in Table VI.

Table VI: Participants' Post-Course Perceptions of Skill in Using Resources

Ability to Implement Instructional Strategies	Percentage					Weighted Average
	None (0)	Little (1)	Some (2)	Much (3)	Expert (4)	
Remote sensing & image processing			33.3	66.7		2.67
Computer simulations & 3-D modeling			33.3	66.7		2.67
Geographic Information Systems & Global Positioning			50.0	50.0		2.50
Real-Time & Real-World Data			16.7	83.3		2.83
Computers & Probeware			33.3	66.7		2.67
Weighted Average for Subcategory						**2.67**

Participants’ perceptions of ability to use the resources were similar for 2006 (2.67) and 2005 (2.53). Ability to use resources is similar across all categories.

After course completion, participants in Section 2 responded to the question: “What did you enjoy most about this course?” Participants cited the range of resources reviewed, discussions among participants, working with people from different backgrounds, and that assignments were beneficial. Participants continued to commend the instructor for his teaching style and the quality of the course materials.

Discussion & Recommendations

As in most web-based courses, the drop-rate was higher than in a face-to-face course. Of the original 21 participants in Section 1, 2 received a WF and 2 received an F. These four participants either began a new job and did not have time or were not committed from the beginning – they saw the course as an “easy way to get recertified.” This trend continued in Section 2 where participants tended to do well in the course (8 A’s, 2B’s) or not perform (3 F’s, 1 Withdrawal), with failing students not completing assignments despite an extension.

Although few weak points were cited, recommendations from Section 1 included more face-to-face meetings to enable sharing, more distributed posting of participants’ information so that more dialogue could occur, and offering the course in the summer when teachers have more time. In Section 2, suggestions for improvement included more time on GIS and GPS and fewer journal entries about websites. In both sections, participants commended the instructor for his teaching style and the quality of the course materials. Based upon this experience, participants should be more closely screened and more intense coursework and deadlines occur earlier in the course to ensure that the individual has a high probability of success or can be withdrawn before the deadline. However, as a pilot course, Drew Keller, Instructor, perceived that the course was effective. In planning the second section of the courses, offered in the summer of 2006, he incorporated these suggestions.

At the January 2006 planning meeting, the course was shown to the course development teams and generated much excitement and interest. Because of viewing the on-line features, other course development teams discussed using “Moodle” (or a system at their university) as a vehicle for collaborative course planning as well as a method for streamlining components of their face-to-face courses including collection of pre-post data. In addition, much dialogue occurred about improving the effectiveness of collaboration among course participants and academic year follow-up through the use of web-based technology.

Conclusion

As part of the Virginia Earth Science Collaborative, a special course on *Integrating New Technologies in the Earth Sciences* (3-graduate credits) was developed and delivered to 35 teachers from across the Commonwealth. Five major technologies were addressed: remote sensing and image processing, real-time and real-world data, computer simulations and 3D modeling, global positioning systems and geographic information systems, and graphing calculators and probes. The course was a blend of face-to-face and web instruction through *Moodle*, a web-based instructional system used by the MathScience Innovation Center (formerly the Mathematics & Science Center). Participants met for two face-to-face sessions on Saturday and completed the remaining instruction through *Moodle*. An initial course was offered in the fall of 2005 and a second course in the spring of 2006. On a pre-post Likert-type survey, participants showed positive increases in their conceptual understanding and skills in the newer technologies, with the strongest gains occurring in use of global positioning systems and geographic information systems and use of real-time and real-world data. Participants identified the modular format of the class, volume and quality of information and resources provided, the interaction with other participants, and the instructor's competence as major strengths. As in most web-based classes, the drop-rate was higher than normal, with participants either performing very well (A's and B's) or making F's because they did not complete assignments. Recommendations for improvement included screening participants more closely for suitability to a web course and having more intense coursework and deadlines earlier in the course to ensure that the individual had a high probability of success (or could withdraw before the deadline). Some participants cited a need for increased interaction through additional face-to-face sessions or more active web-chats and discussions. Overall, the course was a successful pilot and illustrated how a blended face-to-face and web class can be used to meet a statewide audience and to engage participants in active inquiry.