Reform of Introductory Science Courses for Non-Majors

Final Report

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Institution	: Furman University
Title of Project	: Earth from Space: Spatial Science and Technology Focused Introductory Geosciences Course Development and Implementation
Date(s) of Project	: March 2006 to December 2006
Amount Awarded	: $13,235

1. Original Goals and objectives

Main objectives of the project as stated in my proposal are:

a. Introduce geosciences to undergraduate students from a completely different perspective using GIS, GPS, and remote sensing technologies
b. Integrate spatial sciences and technologies into the earth science course to achieve proficiency of scientific concepts among non-science majors
c. Raise the level of science literacy and global awareness of undergraduate students
d. Engage the students at a much deeper level of scientific discussions and understanding by developing course modules and field problem-solving exercises using technologies and tools such as PDA with built-in GPS, and Google Earth.

2. If goals/objectives changed during the course of the project, please state the revised goals/objectives.

The primary goals were not changed from what was proposed but one of the components of the topics proposed to be covered in this course was modified to better fit the course needs. The student project idea as I proposed did not fit the course structure. I originally envisioned few of the lab activities making parts of and contributing to a larger project so that students are progressing through the term to complete the whole project. However, for practical implementation reasons that idea did not work out for the class. Instead, I gave students a project involving global climate change analysis, which they carried out in groups of two. Through this project, they collected and analyzed short term (100's of years) and long-term (1000's of years) yearly climate and other data (CO_2, Temperature, population, solar energy etc.,) and generated graphs and analyzed the results and presented their analysis and conclusions in the form of a brief written report. With the current global focus turning towards this topic, it made sense to educate our students with real scientific data. The students appreciated the idea and the project work.

3. In what ways were the goals/objectives met? Please give examples.

A new introductory course was developed and taught following the general outline provided in the proposal. The students were enthusiastic and interacted well in the class and more participation from students lead to very interesting discussions and tangential exploration of different topics. As the term progressed, I realized that the contents as set forth in the proposal were too much for the duration of the term. However, since I weigh student participation and interaction in the learning process higher than content coverage, I decided not to spend a block of time to discuss the limits and limitations of science and technology. Instead, I wove this topic into the discussions as and when appropriate through the rest of the term.

I incorporated GIS and remote sensing visuals and activities in the class through lectures and laboratory exercises. Three new GIS based lab activities were introduced to the students. One of them related to study of global plate tectonics and distribution of natural hazards such as earthquakes and volcanoes. Students also used Google Earth to identify the type of plate boundary and tectonic process dominant in several locations that were given to them. The second one involved analysis of origin and distribution of mineral and energy resources in the world. For this lab, I gathered the location of mines and mineral processing plants in the world (source: USGS) and identified 12 essential industrial minerals from more than 100 minerals. Then I provided the location of occurrence of those minerals to the students in GIS format along with country boundaries, topography information, and location of major cities. Students spent several hours in the lab and at home studying the locations and researching the origin of those 12 minerals. They submitted a report summarizing their findings with respect to the United States (comparing resource distribution in

different states) and with respect to the whole world (comparing countries). The third GIS lab involved studying water resources in the United States and the world. Students analyzed water availability and consumption patterns by different sectors and their relationship with population, agriculture, and climatic conditions.

The use of PDA in the classroom was explored but not fully realized this term. Some of the technical challenges in making the instrument work in the specific classroom environment lead to minimal usage of PDA and GPS options. However, most of the snags have been identified and rectified and this will be used more in the future offering of this course.

4. Describe the evaluation/assessment process used. Summarize the results of this process? Include any instruments used to evaluate/assess your project.

At the conclusion of each topic within a module, students were given questions to answer that tested whether or not they understood the main concepts discussed. The questions were multiple choice and they used their PDA to answer the question (in the same way as *clicker* technology). The software on the instructor PDA summarized all the answers instantly and displayed it on the projection screen. If the answers were split between students, then the students were paired up and made to discuss the concept under question and then re-take the question. Often, the second time most of them got it right. In situations when several students got the answer wrong, I made sure I spent couple of minutes to go over the concept again. A sample set of questions used are given below:

1. Which of the following is true?
   a. The lithosphere and asthenosphere consist entirely of mantle material.
   b. The lithosphere is the mantle under the oceans; the asthenosphere is the mantle under the continents
   c. The asthenosphere is the upper part of the mantle.
   d. The asthenosphere is more plastic in behavior.
   e. The lithosphere is more plastic in behavior.
2. Which of the following is not true?
   a. Subduction zones are areas where ocean floor descends into the mantle
   b. Subduction zone activity includes very large earthquakes
   c. Subduction zone activity leads to active volcanoes
   d. Subduction zones are areas where ocean floor rocks are formed
   e. Subduction zones are marked the deepest parts of the oceans
3. Which of the following is or was not produced by plate tectonics?
   a. Mid-ocean ridges b. Rift valleys c. "Ring of Fire" d. Appalachian Mountains
   e. Earth's magnetic field
4. What triggers trees to shed leaves during fall season?
   a. Cold rain b. Drop in temperature c. Reduced sun light d. Lack of nutrients
5. What causes seasons to change?
   a. Earth's tilt b. Sun's distance from earth c. Moon's shadow on earth d. None of the above
6. Which of the following rocks display perfect cleavages?
   a. Augen gneiss b. Granite c. Basalt D. none of the above

5. If you were to redesign your project, what would you do differently and why? (What are the "lessons learned?")

1. The biggest lesson I learnt is that one can not do everything to perfection at the first attempt itself.
2. I found that the development of assessment questions was more difficult than I envisioned. Coming up with good questions or methodology is very important to make student participation more meaningful for assessment purpose. Also, I will look for alternate software to install on PDA's to conduct in-class assessment so that it doesn't take more than just necessary time to answer the questions. The software that was used required multiple steps (navigating from one question to another) to answer each question and so too much time was spent just answering these questions and much less time on discussions. I am intending to experiment with "clickers" technology where students only have to click one of the four buttons on a device that they get in the class. Furman already has purchased required h/w and s/w for this and I am going to explore the use of this in my next term teaching of this course.
3. I will further refine the labs and other GIS activities so that they are more effective at getting the students excited, helping them retain their learning longer, and potentially providing some life-changing learning experience.

4. I will enhance the GPS lab to make it more involving. The current exercise involves walking around a small section of the campus that educates students about uses of rocks as economic resources (for constriction or decoration). This could be expanded to other parts, and could be
5. I will constantly look for other ways to improve teaching experience for myself and learning experience for the students.

6. How have you shared the results with ACS colleagues and beyond ACS?

1. I have shared my teaching ideas with Furman faculty through Furman's Center for Teaching and Engaged Learning
2. I have presented my project to ACS colleagues at one of the ACS meetings.
3. I will be posting course materials including lab exercises on the course website.
4. I have been invited to present the ideas I implemented in this course in a science education session at the annual meeting of the Association of American Geographers to be held in San Francisco in April, 2007.
5. *Suresh Muthukrishnan, Earth from Space: Integrating Spatial Science and Technology into Introductory Geosciences Course, Invited Presentation at the Association of American Geographers National Meeting, San Francisco, April 2007.*
6. I am intending to write my experience and lessons learnt through this project and submit it to a journal (such as Journal of Geoscience Education) for publication

7. What are the next steps (follow-up) in your project?

I am intending to spend some time with the educational consultants at Furman's Center for Teaching and Engaged Learning to learn more about the "clickers" technology, and also learn about other creative ways of reaching out to the students to captivate their attention as well as to inspire them towards science learning.

I am intending to introduce "self-reflection" writing component to my classes in the future. The idea evolves from the thought that students these days don't get any time to revisit and ponder as to what they just learnt, and how does it enhance their learning or life? Or where does it fit in? etc. So, the self-reflection time in the class (probably lasting 10 to 15 minutes) will give them the opportunity to write an electronic journal throughout the term about their learning accomplishments and progress. This journal should provide a good account of their educational journey as well as provide them the satisfaction of their own success. This online journal could eventually be transformed into a e-portfolio that is fast catching up on educational institutions.

8. A complete financial statement, showing original budget (the breakdown of the amount awarded) and expenditures.

	Amount Awarded	Amount Spent
Hewlett-Packard 17 HP iPAQ HW6945*	$8535.00	$9836.78
ESRI ArcPad 7 (plus Shipping and handling)	1000.00	1066.83
Faculty Stipend	1700.00	1700.00
Student Stipend	1000.00	1000.00
FICA	0.00	126.67
AAG Conference Registration / Air Travel**	1000.00	463.10
Supplies	0.00	107.49
Total	13,235.00	14,300.10

* The original budget was approved for 15 PDA units. The director of Furman's Computing & Information Services division provided additional money to support purchase of two additional PDA units.
** Hotel reservations and other transportation arrangements need to be done.

9. Please include a statement than you give ACS permission to post your original proposal and the results of your work on the ACS Science Reform website.

I, Suresh Muthukrishnan, am here by authorizing ACS to use the contents of my proposal and the results obtained as they fit necessary for educational purpose.

I have attached a copy of my course syllabus for your use.

EES 11C EARTH SYSTEM (EARTH FROM SPACE)

Instructor: Dr. Suresh Muthukrishnan | Office: Riley Hall 109A, Phone: 3361
Lecture Hours: 9:00 to 9:50 AM, M to F | Lab Hours: Tuesdays, 2:00 to 5:00 PM
Email: suresh.muthukrishnan@furman.edu | Web: http://ees.furman.edu/ees11sm

Text: Custom text book prepared specifically for this class. This will be available from EES dept. office soon.

Objectives: To introduce Earth Systems Science by providing basic understanding of different components of the system and their significance; to facilitate engaged learning through interactive classroom and field based studies; and to instill environmental consciousness and awareness. One of the main objectives of this course is to understand the Earth processes and resources and their relationship to human environment and needs. To achieve this, we will be using satellite images of different parts of the world, Geographic Information System (GIS) based data, and collect your own GIS data using Global Positioning Satellite (GPS) system. We will also use latest technology (PDA/GPS/Digital Camera combo) in the classroom to enhance and improve learning.

Requirements for the Class:

- You must read assigned reading materials before related class begins.
- Maximum 3 unexcused absences allowed; thereafter grade will be reduced part of the letter grade (for example, B- to C+) for each additional absence
- Attendance in all labs (if you miss any, you will get incomplete grade).

Course Expectations:

- Give your best – nothing less than 100%. Your grade in the exam reflects how well you prepared, don't blame others for your failures. Instead, work harder and improve your style of learning. If you don't understand something, ASK Questions!
- Attendance in the class and participation in classroom activities (discussions, asking questions etc.) is a must along with good performance in tests to guarantee top grade.
- I expect you to submit assignments and reports by the due date and time. Late submissions will be accepted, but 20% will be taken off for each day delayed – "irrespective" of the reason for the delay.
- Do not miss exams. No make-up exams will be given, except under unusual circumstances.
- Helping you is my first and foremost priority, so NEVER hesitate to ask me for help.

Grading Policy:

4 exams	- 60 %
Assignments/Quiz/Project	- 20 %
Lab	- 20 %
Total	100 %

Final grade will be based on the following scale:

> 96 A+	86 – 90 % B+	76 – 80 % C+	66 – 70 % D+
93 – 96 % A	83 – 86 % B	73 – 76 % C	63 – 66 % D
90 – 93 % A-	80 – 83 % B-	70 – 73 % C-	60 – 63 % D-

STUDENTS WITH SPECIAL NEEDS: If a student with a disability desires an accommodation, it is the student's responsibility to identify him or herself as having a disability and to make a formal request for appropriate accommodations. The Disabilities Services Coordinator at Furman is Ms. Donna Taylor at extension 2322.

ACADEMIC DISHONESTY: Academic dishonesty in any form is a fundamental offence against the integrity of the entire academic community and is always a threat to the standards of the college and to the standing of every student. In taking examinations, doing homework, laboratory work, and writing papers, students are expected to perform with honor. One of the most common forms of academic dishonesty is plagiarism. Plagiarism is the use of another's words and ideas as if they were one's own. To avoid plagiarism, students should acknowledge their sources, using whatever documentation is appropriate to the discipline in which their work is being done.

Some Study Guides:

- **Lecture Note Taking** Very helpful information on note taking from Northwest Learning Grid at *http://www.nwlg.org/pages/resources/knowitall/studyskills/notes.htm*
- **Editing Lecture Notes** Helpful one-page handout explaining how to review and improve notes after lecture issued by Virginia Polytechnic Institute, Division of Student Affairs *http://www.ucc.vt.edu/stdysk/editing.html*
- **How to Study Math and Science** Helpful one-page handout concerning how to study math and science issued by University of Texas at Austin Learning Center *http://www.utexas.edu/student/utlc/handouts/862.html*

TENTATIVE SYLLABUS (SUBJECT TO REVISION)

Note: Your instructor reserves the right to modify the syllabus as required as the term progress.

Week 1: Plate tectonics and natural hazards (Hazards associated with PT) (4 hours)

Week 2: Plate tectonics and natural hazards (Hazards associated with PT) (5 hours)

Week 3: Plate tectonics and natural hazards (Hazards associated with PT) (5 hours)

Week 4: Occurrence, characteristics, identification, and management of natural resources (5 hours)

Week 5: Occurrence, characteristics, identification, and management of natural resources (5 hours)

Week 6: Occurrence, characteristics, identification, and management of natural resources (5 hours)

Week 7: Global climate and atmospheric & ocean circulation (4 hours)

Week 8: Global climate and atmospheric & ocean circulation (3 hours)

Week 9: Human influence on the local and global geologic processes (5 hours)

Week 10: Human influence on the local and global geologic processes (5 hours)

Week 11: THANKSGIVING WEEK

Week 12: Human influence on the local and global geologic processes (5 hours)

Week 13: The Limits and Limitations of Science and Technology (3 hours)

Lab 1 – GIS based investigation of plate tectonics and earthquakes (September 19) w2

Lab 2 – Rocks and Minerals (in class), and Upstate geological history (field trip) (October 3) w4

Lab 3 – Energy Resources (in class) (October 17) w6

Lab 4 – Climate change (in class), GIS based investigation of hurricane hazards (October 31) w8

Lab 5 – GIS based investigation of water resources (November 14) w10

Lab 6 – Project presentation (November 28) w12