Implementation Summary

Project Goals & Funding

Based upon the needs assessment, the Virginia Earth Science Collaborative (VESC) developed four project goals:

1. Increase the pool of endorsed earth science teachers by offering the coursework needed for the Add-On Earth Science Endorsement in various geographic areas of Virginia;
2. Increase teachers' conceptual understanding of the Earth Sciences and their ability to deliver inquiry-oriented instruction by developing and offering Earth Science courses appropriate for teachers;
3. Increase the number of highly qualified Earth Science teachers by piloting courses in three identified need areas: use of effective strategies including new technologies, improved collaborative teaching of Earth Science, and a targeted course for sixth grade teachers;
4. Establish a statewide collaborative that can be used to continuously lead and inform decisions and programs related to the teaching and learning of Earth Science.

A proposal based upon these goals was submitted to the Virginia Department of Education and funding of $920,848 was awarded for the period of March 2005 to September 2006. Based upon the success of the project, a second award of $351,649 was made between March 2006 and September 2007. Finally, a special award of $35,017 enabled development and funding of a special issue of this journal. A total of $1,307,514 in MSP funding was matched by $237, 000 from the VESC partners.

Implementation

Goal 1: Increase the Pool of Endorsed Earth Science Teachers. Before admission to classes, all teachers completed the *Teacher Survey*, which included their reason for participation. When necessary, these reasons were used to establish priorities for enrollment. Demographics on participants reflect the priorities:

1. Secondary science teacher completing an Earth Science or Add-On Earth Science endorsement, with priority given to those currently teaching earth science (53% of participants);

2. Middle or special education teacher taking 18 credit hours towards the full Earth Science endorsement (16% of participants);

3. Middle or special education teacher taking earth science courses to strengthen their background (13% of participants);

4. Endorsed earth science teacher taking courses to strengthen their background, especially *Geology of Virginia* and courses which they may have taken in a non-laboratory setting (10% of participants);

5. Other participants included pre-service or career switchers in degree programs and upper elementary teachers whose curriculum included earth science topics (8% of participants).

Because large numbers of elementary, middle and special education teachers were applying to take the courses, these priorities were established in cooperation with the Virginia Department of Education. Although the primary purpose of the grant was to increase the number of endorsed earth science teachers, strengthening the academic background of teachers in the feeder curriculum was perceived as a critical way to improve the overall quality of the earth science curriculum. Initially, professors at the universities were hesitant to enroll teachers outside the target population, and their advice was asked regarding the best courses for students to take, with the recommendations being Astronomy, Meteorology and Physical Geology. Of these courses, Astronomy and Meteorology had the greatest application to Virginia's upper elementary and middle school science curriculum.

Five courses were developed and delivered statewide as shown in *Table I: Participation in Courses for Add-On Earth Science Certification.*

Table I: Participation in Courses for Add-On Earth Science Certification.

Information	**Astronomy**	**Meteorology**	**Oceanography**	**Geology I - Physical Geology**	**Geology II – Geology of Virginia**	**Total**
Number of different locations taught	4	3	4	4	5	---
Number of course sections	7	6	6	5	9	33
Number of participants	134	115	79	64	107	499

Percentage (%) of participants	27	23	16	13	21	100
Participants' reasons for taking course (%)						
Secondary science teacher completing or adding an earth science endorsement (%)	38	52	71	66	50	53
Middle or special education teacher completing 18 credit hours (%)	13	18	13	22	17	16
Middle school or special education teacher strengthening background (%)	20	16	8	8	9	13
Endorsed earth science teacher strengthening background (%)	16	5	6	1	18	10
Other – pre-service teachers, elementary teachers, etc. (%)	13	9	2	3	6	8

Courses were taught at seven different locations within the state: Abingdon, Charlottesville, Fairfax, Harrisonburg, Radford, Richmond, and Williamsburg. The seven institutions of higher education delivering courses at the various locations were:

- College of William & Mary: Richmond and Williamsburg;
- George Mason University: Fairfax;
- James Madison University: Harrisonburg;
- Longwood University: off-site campus in Richmond area;
- Radford University: Radford;
- University of Virginia and its School of Continuing Education: Abingdon, Charlottesville, and Richmond;
- Virginia Commonwealth University: Richmond.

Thirty-three courses sections were offered by these institutions including 9 *Geology of Virginia*, 7 *Astronomy*, 6 *Meteorology*, 6 *Oceanography* and 5 *Physical Geology*. In the sections, there were 499 participants (duplicated count), with the largest percentages enrolled in *Astronomy* (27%), *Meteorology* (23%) and *Geology of Virginia* (21%). Several factors contributed to the higher enrollment in these courses: astronomy and meteorology are major components of the elementary and middle school curriculum, geology and its applications to Virginia comprise over 50% of the earth science curriculum, and meteorology was a web-based class. Enrollment was much smaller in *Oceanography* (16%) and *Physical Geology* (13%), with the classes taken primarily by

teachers pursuing an earth science endorsement. For example, 88% of the physical geology participants and 84% of the oceanography participants were secondary teachers pursuing the endorsement or middle and special education teachers pursing 18 hours towards the endorsement. In addition, many participants had taken physical geology as an undergraduate.

Goal 2: Increase Teachers' Conceptual Understanding of the Earth Sciences. In response to the RFP, 5 graduate courses specifically designed for teachers were targeted for development: *Astronomy*, *Meteorology*, *Oceanography*, *Geology I: Physical Geology* and *Geology II: Geology of Virginia*. With the exception of the geology sequence, courses could be taken in any order. Guidelines for development included addressing the areas of Earth Science required in the RFP, emphasizing inquiry and the nature of science, and providing extensive opportunities for teachers to engage in field studies. For example, the *Oceanography* course included a two to three-day intense experience at the Virginia Institute of Marine Sciences' (VIMS) research station on the eastern shore and the *Geology of Virginia* course included field experiences in the geologic provinces.

Five course development teams were formed to develop each of the designated courses, with each team led by a professor charged with appointing team members, scheduling meetings and discussions, compiling products for review and dissemination, and managing the course development budget. As an initial step, each team developed general information about the course including the curriculum framework concepts, related *Standards of Learning* objectives, and examples of how inquiry and the nature of science would be addressed (see Table II). The composition of the various teams is provided below:

- *Astronomy*: Edward Murphy, Assistant Professor at the University of Virginia led the team. Members included Harold Geller of George Mason University, Randy Bell of the University of Virginia, David Hagan of the Science Museum of Virginia, and Michael Bentley of the University of Virginia's School of Continuing Education.
- *Meteorology*: Juanita Jo Matins, Associate Professor at the College of William & Mary led the team. Members included Eric Pyle of James Madison University, Jo Ann Mulvaney, Adjunct Professor for Virginia Commonwealth University, and Michael Bentley, Adjunct Professor for the University of Virginia's School of Continuing Education.

Table II: Overview of Courses for Earth Science Endorsement

Geology I: Physical Geology (4 credits) Curriculum Framework Concepts: Identification and use of minerals, rock cycle processes, weathering, erosion, deposition, metamorphism, melting, crystallization) and products (igneous, metamorphic, sedimentary rock identification), plate tectonic processes (subduction, rifting, continental collision) and their relationship to the rock cycle, influence of surficial process on soil development and local geomorphology, age of Earth, basic stratigraphic principles and relative time. Related SOL: ES 1c; ES 3; ES 5; ES 6; ES 8 b, c; ES 9 a, b, c, d; ES 10 a, b, c. Examples of Inquiry Skills & Nature of Science. Classification of minerals and rocks, interpretation of rock cycle diagram, development of concept maps relating rock cycle and plate tectonics, interpretation of topographic maps.
Geology II: Geology of Virginia (4 credits) Pre-requisite: Geology I: Physical Geology Curriculum Framework Concepts: Relationship between plate tectonic processes and geologic hazards (earthquakes, volcanic eruptions), structure geology (faults, folds), paleomagnetism and the geologic time scale, fossil identification and use, geologic history and the resulting physiographic provinces and resources of Virginia. Related SOL: ES 1 b, c, e: ES 2: ES 3, ES 7 c, d, e; ES 8, ES 9 f; ES 10. Examples of Inquiry Skills & Nature of Science. Local and regional field studies of Virginia's physiographic provinces and resources, fossil identification, interpretation of geologic maps, development of field guides by teachers for teachers.
Oceanography (4 credits) Curriculum Framework Concepts: Tectonic evolution of the ocean basins, physiography of the sea floor, heat capacity of the ocean and influence on maritime climates, waves, tides, influence of winds on surface currents, upwelling, relationships between sea level change and climate and tectonics changes, influence of temperature and salinity on density and deep water circulation, coastal geology, marine ecosystems, controls on marine sedimentation, microfossils and ancient oceans, marine resources. Related SOL: ES 1; ES 2; ES 3; ES 4b; Es 7 a, d, e; ES 8 b, c: ES 10 a; ES 11; ES 13 d. Examples of Inquiry Skills & Nature of Science. Intense field experiences at VIMS Field Station including shipboard physical, chemical, and biological analyses of saltwater ecosystems, marine depositional environments, currents and tides, long shore transport, barrier island dynamics, and fisheries.
Meteorology (3 credits) Curriculum Framework Concepts: Earth's heat budget and global wind patterns, weather vs. climate, radiation, convection, cloud formation, the hydrologic cycle, vertical structure of the atmosphere, orographic effects on weather, severe weather, the influence of life (microbial, human) and geologic processes on atmospheric composition and temperature through geologic time, comparison of the atmospheres of Earth, Mars, and Venus. Related SOL: ES.1, ES.3 a, b, c, d; ES 9 d; ES.11 c, ES.12 a, b, c, d, e; ES 13 a, b, c, d. Examples of Inquiry Skills & Nature of Science. Through the use of Internet accessed real-time and near real-time data, hands-on activities, lab experiences and field experience the course will focus on inquiry-based learning and the applications of experimental design in meteorology. The course will feature an examination of current understandings of climate change and how these understandings reveal the nature of the scientific enterprise and scientific knowledge.
Astronomy (3 credits) Curriculum Framework Concepts: Position and motion of Earth in space, sun-Earth-moon relationships and the resulting seasons, tides, and eclipses; characterization of solar system bodies (sun, planets, meteors, and asteroids), formation and evolution of the universe (big bang theory) and solar system (solar nebular theory), life cycle of stars, nature of space exploration and study (ground based observations Vs space based observations), major contributions of the space program. Related SOL: ES 1; ES 2; ES 3; ES 4; ES 14. Examples of Inquiry Skills & Nature of Science. Computer-based labs and simulations such as Starry Night, planetarium work, night-sky observations.

- *Oceanography*: Kristen St. John, Associate Professor at James Madison University led the team. Members included Mark Krekeler of George Mason University, Vicki Clark of the Virginia Institute of Marine Science, Steve

Oden, Adjunct Professor at Virginia Commonwealth University and educator at the MathScience Innovation Center, and Chris Lundberg, educator at the MathScience Innovation Center.

- Geology Courses*:* Because the two geology courses were sequential and many professors were teaching both courses, the group met collectively to determine the scope and sequence of each course. Heather MacDonald, Professor at the College of William & Mary led the initial discussions which included Gerald Johnson and Brent Owens of the College of William & Mary, Rick Diecchio of George Mason University, Eric Pyle of James Madison University, Joyce Watson of the MathScience Innovation Center, and Jonathan Tso of Radford University. In the first summer, *Physical Geology* was offered with Eric Pyle providing leadership for course development; Rick Diecchio, Joyce Watson, Jonathan Tso and two professors at James Madison University, Roddy Amenta and Lynn Fichter, assisted him. For *Geology of Virginia*, Heather MacDonald provided leadership for the team, which consisted of Gerald Johnson, Brent Owens, Rick Diecchio, Eric Pyle, Joyce Watson, and Jonathan Tso.

Goal 3: Increase the Number of Highly Qualified Earth Science Teachers. As previously described in the Needs Section, teachers recommended three major ways to improve their capabilities in the Earth Sciences and to improve student achievement. First, 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.

Second, numerous divisions and teachers from high need schools expressed a need for more effective collaboration involving special needs students. Comments were that special education teachers needed a greater understanding of Earth Science concepts and that the regular classroom teacher needed a greater understanding of appropriate differentiation strategies for various special education students, slow learners, and poor readers. To meet this need, *Effective Collaboration in the Earth Science Classroom*, was developed and piloted in the summer of 2006 at Longwood University's off-campus site in Powhatan County, which is located west of Richmond. Teachers from schools with less than a 70% pass rate Earth Science SOL Test were given priority for enrollment. Enza McCauley, Science Education, and Peggy Tarpley, Special Education, combined

their expertise to develop the course, which was offered for 3-graduate credits through Longwood University's School of Education.

Third, sixth grade teachers expressed a need for a general Earth Science course focused on the major concepts included in the sixth grade curriculum. When advertised in the spring of 2006, insufficient enrollment occurred. An informal survey of participants who had originally expressed an interest revealed that many had enrolled in *Astronomy* or *Meteorology* and preferred to take these in-depth courses, rather than a general survey. For this reason, course development was cancelled.

Finally, a non-college credit course was developed by the MathScience Innovation Center to enable earth science teachers, and their students, to develop and implement virtual field trips to various geologic sites within their community. As part of the *Integrating New Technologies in Earth Science* course, creation of virtual field trips was introduced; however, the resulting products were of poor quality and the instructor recommended that a separate course be developed. Three members of the MathScience Innovation staff combined their expertise to develop a new course, *GeoVirginia: Creating Virtual Field Trips*, which was offered for 45 non-college credits. John Sylvester provided leadership in developing the content management system and initial course; Joyce Watson provided expertise in earth science; and, Echol Marshall provided expertise in videography and development of a web-based course. The course was piloted in the summer of 2007 and offered a second time in the fall of 2007.

As shown in Table III, five sections of the pilot courses were offered with 74 teachers enrolled. Although the pilot courses were offered in the Richmond area, the fact that two of the courses were web-based enabled statewide participation. Participants in *Integrating New Technologies in the Earth Sciences* attended two face-to-face sessions on Saturday and completed the remaining work via the web. In the first *GeoVirginia Course*, participants attended a two-day face-to-face session and then spent a month completing projects, with on-going follow-up provided via the web (*Moodle*) or individual sessions with instructors. In the second *GeoVirginia* course, only one Saturday face-to-face session was held, with the remaining work occurring via the Center's videoconferencing system (*Elluminate Live*), *Moodle*, or individual videoconferences.

Table III: Participation in Special Topics Earth Science Courses

Information	**Integrating New Technologies**	**Effective Collaboration**	**GeoVirginia: Virtual Field Trips**	**Total**
Number of different locations taught	1	1	1	
Number of course sections	2	1	2	5
Number of participants	35	13	26	74
Percentage of participants (%)	47	18	35	100
Participants' reasons for taking course (%)				
Secondary science teacher completing or adding an earth science endorsement (%)	43	0	23	19
Middle or special education teacher completing 18 credit hours (%)	6	0	8	6
Middle school or special education teacher strengthening background (%)	0	54	4	10
Endorsed earth science teacher strengthening background (%)	31	15	65	50

Other – pre-service teachers, elementary teachers, technology specialists, etc. (%)	20	31	0	15

In the pilot classes, the majority of participants were in the *Integrating New Technologies* course (47%). Although the target audience was endorsed earth science teachers, they comprised only 31% of the population. Even though it did not count towards the endorsement, some middle and secondary teachers enrolled to immediately improve their ability to use technology with their students (49%). Unexpectedly, technology resource teachers (20%) also enrolled.

Again, although the target audience for the *GeoVirginia* class was endorsed earth science teachers, they comprised only 65% of the population. Because examples of virtual field trips were posted on the web, students in the summer 2007 *Geology of Virginia* classes learned about the site and wanted to immediately begin making products. These motivated teachers made up 31% of the class and created virtual field trips based upon their summer experiences.

Enrollment in the course on *Effective Collaboration in the Earth Science Classroom* was disappointing. Beginning with an over-subscribed class of 35 students in the spring, the class dropped to 13 participants by the August 2006 class. The class consisted primarily of special education and elementary teachers, with few endorsed earth science teachers electing to participate. During the time that the course was developed and implemented, the Virginia Department of Education was refining requirements for content coursework by special education teachers. Initially, many teachers saw the course as a way to meet the state requirements and enrolled; however, as school divisions developed local options for meeting the requirement, they "dropped-out," with many being "no-shows" on the first day of class.

Goal 4: Establish a Statewide Collaborative. The collaborative of 7 institutes of higher education and 2 non-profits involved in the Virginia Earth Science Collaborative included major institutions from all geographic areas of the state. All participants had representatives on the staff and board of the Virginia Mathematics & Science Coalition. In addition, various subsets of the institutions had partnered previously on NSF and MSP grants that focused on teacher preparation and licensure, an Inter-Institutional Master's Degree for middle school math and science teachers, and various programs related to licensure and a Statewide Master's Degree for K-8 Math Specialists. Because none of these grants had fostered development of strong partnerships in the sciences, the partners viewed establishment of a statewide network in the sciences as a major outcome.

Steering Committee. The Virginia Earth Science Collaborative Steering Committee provided overall leadership and guidance for the grant. Led by the project director, Julia Cothron, the committee consisted of 26 active members including 12 professors from Arts & Sciences, 6 professors from Schools of Education, 5 educators from the K-12 community, and 3 members from museums and higher education administration. To facilitate implementation, a site leader was appointed for each of the major institutions, e.g. College of William & Mary, George Mason University, James Madison University, MathScience Innovation Center, Radford University, and the University of Virginia & its School of Continuing Studies. Each site leader was responsible for achieving site objectives for course development and implementation, developing liaisons with area schools, interacting with the external evaluator, and

administering the subcontract budget. The project director and site directors interacted regularly through teleconferences and electronic mail.

During the first 18-months of the grant, the group met 4 times. The grant was funded in March 2005, with steering committee meetings occurring in March and June of 2005. Because members were most concerned about course implementation in the summer of 2005, the two initial meetings focused on course development, assessment, teacher recruitment and registration, and information about the variety of resources available through the Virginia Department of Education including the *Standards of Learning for Earth Science*, test blueprints [5], and released test items [6]. In January 2006, the committee met to discuss concerns that had emerged during the first year of the grant, to develop appropriate modifications for future coursework, and to develop a sequence of courses for the second phase of the grant, from September 2006 to September 2007. Major concerns included developing quality tools for assessing participants' achievement of course objectives, developing effective ways to support classroom implementation, and improving recruitment in specific areas of the state. Because these concerns varied among institutions, various subgroups of the Steering Committee assumed responsibility for addressing. In September 2006, the Steering Committee met as part of the *Spotlight on Earth Science Conference* and began the transition to an Earth Science Committee under the leadership of the Virginia Mathematics & Science Coalition. During the last year, the grant leadership interacted through teleconferences and e-mail and the various course-development leaders met face-to-face or electronically with team members. In addition, a web-based *Moodle* site was established for on-going posting of materials and dialogue among members.

Coalition Committee. In October 2006, the Virginia Mathematics & Science Coalition approved establishment of an Earth Science Committee to provide leadership on issues related to teacher licensure and training, state standards and their assessment, and other policy issues. Dr. Eric Pyle of James Madison University and Dr. Edward Murphy of the University of Virginia agreed to co-chair this committee; both of these individuals were site leaders for the Virginia Earth Science Collaborative. Under their leadership, an active committee was established and regular reports provided at the Coalition's meetings, which occur 3 to 4 times annually.

Web Site. In the spring of 2005, a project web site was launched to provide information about the goals and objectives of the grant, requirements for the full and add-on Earth Science endorsements, course development, teacher eligibility, course schedules and registration. As needed, this site was updated throughout the grant. In the summer of 2007, the site was expanded to include electronic articles about courses offered throughout the state. In the fall of 2007, the site was modified to include a section entitled *GeoVirginia*, which includes virtual field trips to various sites across Virginia.

Implementation Summary