Dan Barstow
TERC

TERC's Center for Earth and Space Science Education (CESSE) creates innovative materials for Earth and space science education, featuring science as inquiry, Earth as a dynamic system, and interactive visualizations. Several of these projects involve partnerships with other institutions and all have some form of embedded professional development.
Examples include:

* *Exploring Earth* -- web-based investigations and visualizations in collaboration w/McDougal Littell's widely used high school Earth science program
* *ISS EarthKAM* - students control a digital camera on the International Space Station
* *GLOBE* - students worldwide conduct environmental measurements for use by scientists
* *Mars Quest Online* - students investigate Mars with images from NASA Mars missions.

CESSE also conducts professional development in Earth science in two innovative programs:
Earth Science by Design - inquiry-based professional development in the "big ideas" of Earth science, based on the principles of "Understanding by Design" (contact Harold_McWilliams@terc.edu)
Earth Science from a new Perspective - on-line professional development program engaging teachers in Earth science investigations, focusing on the Nile River as a deep example (contact Sue_Doubler@terc.edu)
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CESSE also produced the report of the National Conference on the Revolution in Earth and Space Science Education (along with Dr. Ed Geary, PI). This report sets the larger stage for the "revolution" in Earth and space science education in which scientists, educators, policy-makers and professional organizations are at work. Visit the webpage containing the full report and more information, or download a PDF of the Executive Summary.

Celeste Carty
Science Magnet School, Minneapolis

Crossroads Science Magnet: Facilitating Scientist-Teacher-Student Partnerships

Co-teaching Scientists and Teachers in the Classroom is an innovative professional development program for teachers, enabling educators to acquire topical science content knowledge by working side by side with a scientist for a period of weeks in their own classroom. Program implements global change curricula developed by NASA and is sponsored by Global Environmental Strategies, NASA, and the Limnological Research Center, Institute of Technology, University of Minnesota. Current projects include school year co-teaching activities

during intersessions in this year-round school.
I. *Intersession Science Instruction (2000-) Crossroads Science Magnet*
Examples of 2 week Earth education programs piloted K-1: Our very own Star, the Sun; Grade 2: Echo the Bat (biology/remote sensing), Grade 3: Earth Greenhouse (environmental science), Grade 4: A Water Planet, Grade 5: Dynamic Earth, Grade 6: Remote Sensing Grades 3-4: Math, Earth science and the Underground Railroad.
In a variant of the Co-teaching program, in conjunction with the NASA NOVA course offered at UMN, Crossroads will have pre-service teachers teaching about Earth science topics during intersession, working with in-service teachers (2003-2004)
II. *Earth System Science Education Alliance*: www.cotf.edu/products/main.html
7 teachers at Crossroads participated in NASA's graduate on-line Earth system science course (2002)
III. *NASA Explorer School*
Combination of these activities have resulted in one teacher applying for and getting a grant to develop Montessori activities in Earth system science (Brenda Petta, 2003), and has contributed to Crossroads being selected as one of the nation's NASA Explorer schools (2003). Five teachers and university scientist will spend one week at Glen this summer receiving professional development as the Explorer School teaching team.

Robert Cichowski
Associate Director, Teacher Preparation and Public School Programs
California State University Office of the Chancellor

Preparing Secondary Science Teachers and Science Competent Elementary Teachers in California

The California Council for Science and Technology's Report "Critical Path Analysis of California's Science and Technology Education System" (April 2002) has documented that California falls short by 14,000 science and engineering graduates in meeting the hi-tech needs of the state. California's share of U.S. science and technology employment has ranged from 15-18% over the last twenty years. The "Critical Path Analysis" report examines each component of the California educational system, from kindergarten through graduate school, identifying the system's strengths and weaknesses and finding the bottlenecks in the educational pipeline that are preventing more young Californians from obtaining college degrees. There are perceived to be significant problems in the preparation of K-12 students, particularly in math and science. California is experiencing a growing shortage of qualified teachers, especially in science and mathematics. Improving teacher quality, particularly at low performing schools, is an important key to improving student performance.
California has moved to correct the situation. After creating the California K-12 Academic Content Standards in Science in the late 1990s the "Standards of Program Quality and Effectiveness for the Subject Matter Requirement for the Multiple Subject Teaching Credential" were created and approved (September, 2001) and most recently "Single Subject Matter Standards: Science" (February, 2003).
The 23 California State University campuses (400,000 students) are in the process of revising teacher preparation programs and insuring that the earth and space sciences are an integral part

of the Subject Matter Preparation. See the document "Single Subject Matter Standards: Science" in its entirety, and "Standards of Program Quality and Effectiveness for the Subject Matter Requirement for the Multiple Subject Teaching Credential" (particularly, "Content Specifications in Science" starting on p. A17 of latter document).
In the last year the California Sate University has entered into a collaboration with NASA with the hopes of developing new secondary science and math teacher preparation programs which will meet the need for more and better prepared secondary science and math teachers.

Susan M. DeBari
Geology Department and Science, Math, and Technology Education Program
Westerrn Washington University

K-12 Geoscience Teacher training at Western Washington University

Introduction and Background
The Science, Math, and Technology Education (SMATE) Program at Western Washington University offers a high quality teacher-training program for pre- and in-service K-12 teachers. The Geology Department plays an integral role in this program, as do all the other science departments. Two faculty members from each of the science departments have split appointments with the Program, as well as representatives from math and engineering technology. In geology, these are Susan DeBari and Scott Linneman. The SMATE program is engaged in the reform of undergraduate courses in the respective disciplines as well as in education. Building on their research expertise, the faculty works as a multidisciplinary team while exploring how to provide the best training and support for future teachers. The program is housed in the Science, Math, and Technology Education Building, a state-of-the-art facility with wired classrooms, a Learning Resource Center (LRC) with computers and high quality curricular materials, a fabrication lab, and a storeroom stocked with teaching supplies. The LRC is open for review and checkout of materials by students as well as practicing teachers in the local community (often alumni of Western's teaching program).
Recruiting, mentoring, and advising future teachers
Susan DeBari and Scott Linneman are the geology education faculty that act as academic advisors and mentors for future teachers in Earth Science. The pre-service teachers consist of undergraduates, post-baccalaureate students, and Masters in Teaching candidates. In Washington State, a future science teacher gets a certification to teach in secondary school, and an endorsement to teach a particular science. To teach geology, one must have an Earth Science endorsement or an Earth Science/General Science endorsement. The state requirements for these two endorsements (along with the Western courses that satisfy the requirements) can be found by clicking on the appropriate link on the endorsement web site.
Recruiting for undergraduate students is typically done within the geology department and at nearby community colleges. Once they are at Western, they are mentored and advised by the two geology education faculty and choose one of three majors designed specifically for future teachers. These are B. A. in Education, Earth Science - Elementary; B.A. in Education, Earth Science - Secondary; and B.A. in Education, Earth Science/General Science - Secondary. This latter one means that a student is endorsed to teach any secondary science, but with an emphasis on Earth Science. They are also mentored and advised by faculty from the Woodring College of

Education (it is a dual college program). A typical advising sheet for science-related coursework can be found here and here.

Western Washington University also has a post-baccalaureate and a Masters in Teaching program for people with Bachelor's Degrees who want get teacher certification. We recruit candidates from Western's pool of geology graduates, graduates of the other Washington universities, and those who are making mid-life career changes. They are also advised and mentored by the geology education faculty.

The role of introductory courses in teacher preparation

In the geology department at Western, there are two introductory courses in geology. One (Geology 101) is for non-science majors (including future elementary teachers), and the other (Geology 211) is for science majors and future science teachers. The biology, chemistry, and physics departments also have this same split (100 level vs. 200 level). For Earth Science pre-service teachers, two quarters of the lower-level introductory physics (non-calculus based) is required, two quarters of the upper level introductory chemistry, and the 200 level geology sequence (physical and historical). The same is true for Earth Science/General Science majors, except that a year each of introductory Physics (100 level), Biology (200 level), and Chemistry (200 level) is required. Thus, other than physics, pre-service science teachers are taking the same introductory science classes that the science majors are taking. At the present time, there are no introductory courses geared specifically for teachers, but this is expected to change in the next few years.

Research and teaching experiences for future teachers

Teaching experiences: both the elementary and secondary education programs have a wealth of teaching experiences as part of the major. All future elementary teachers must take a science methods course taught by SMATE faculty that is followed up by a quarter-long teaching practicum in science in a local elementary school. Secondary education majors have a short teaching practicum during their coursework, and then spend 26 weeks doing their teaching internship at a local school. The SMATE faculty observe and mentor these students while they are in the schools. In the past year, half of the teaching internship placements were for students with Earth Science/General Science endorsements.

Research experiences: At the present time, a universal research experience for pre-service secondary teachers in Earth Science is limited to classes. The secondary science methods class requires students to do an interdisciplinary marine intertidal research project at a local beach, and several of the required geology classes require independent field-based research projects. However, scholarships are available for future teachers to work in a faculty member's lab as a summer intern.

For future elementary teachers, a new interdisciplinary capstone science course (The Nature of Inquiry) has just been approved by the university. This course is entirely inquiry-based, so that these future teachers will gain experience in formulating research questions, gathering and analyzing data, and presenting results.

The Washington Earth Science Initiative is a summer program that exposes teachers to inquiry learning and how it can be applied to their classrooms. These teachers then develop long-term, field-based research projects that they can do with their students throughout the school year. Constructing Physics Understanding is also a summer programs that exposes teachers to inquiry-based learning.

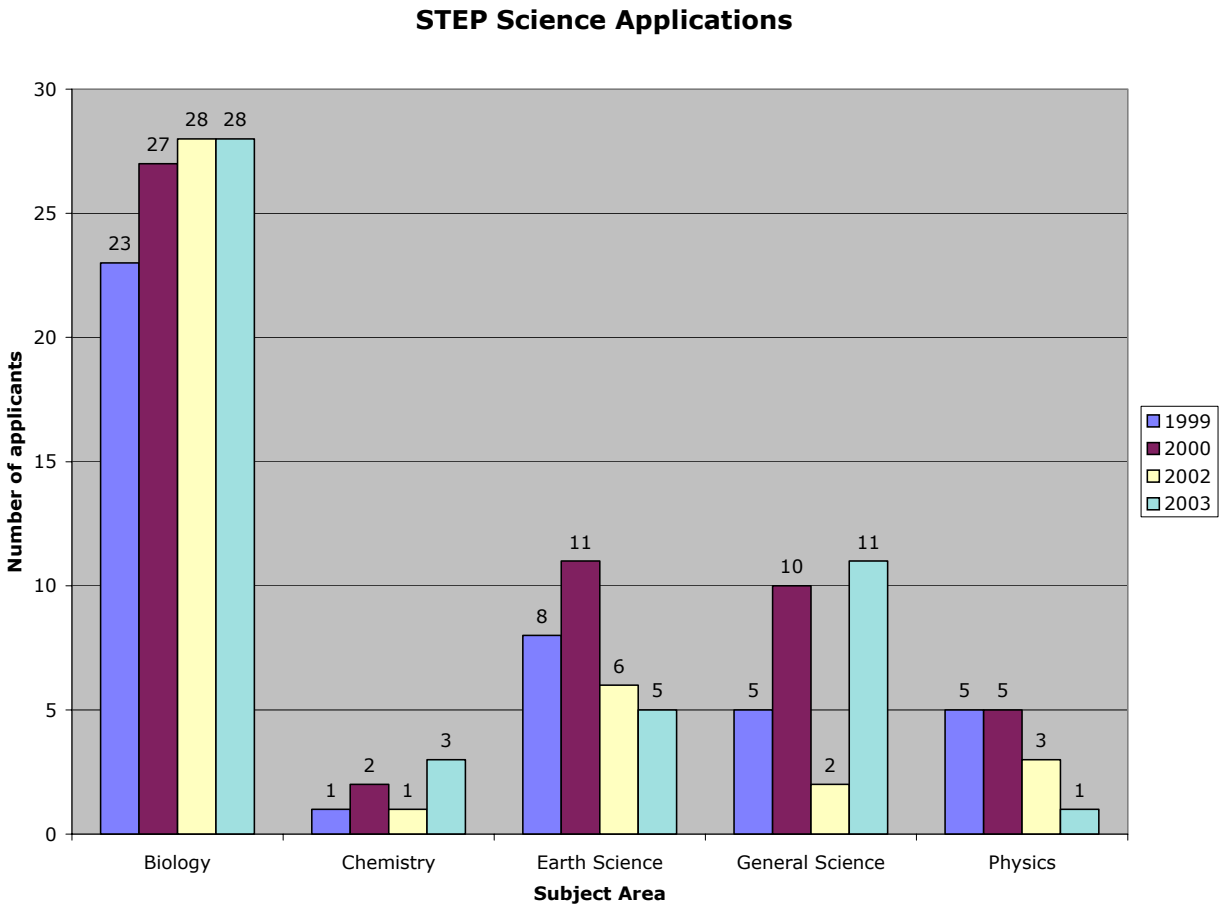
Links between education and geoscience departments
As mentioned above, there is a strong link between the School of Education and the Geology Department at Western in that the department offers three majors specifically for future teachers. Certain courses have also been specifically targeted for future teachers. These include Oceanography and Meteorology (now required by the state for a teaching endorsement in Earth Science). Another course, Earth Materials, was designed specifically by Scott Linneman for teachers in lieu of the traditional two-quarter sequence of mineralogy and petrology. Outreach programs, such as the Washington Earth Science Initiative mentioned above are also offered through the auspices of the Geology Department at Western, and are organized by geology science education faculty.

Allan Feldman
University of Massachusetts -- Amherst

Earth science teacher preparation at UMass Amherst

The Secondary Teacher Education Program (STEP) of the School of Education provides teacher preparation in secondary science at the University of Massachusetts Amherst (UMass). There are currently six tracks that a licensure student can follow, all of which use the same sequence of education courses and practica (http://www.umass.edu/teachereducation). These tracks are undergraduate, post-baccalaureate non-degree, post-BA/BS Summer/Fall (http://k12s.phast.umass.edu/~stemtec/SummerFall), M. Ed. on-campus, M. Ed. off-campus, and graduate student in another unit of the University. Massachusetts' regulations for initial license in earth science require that candidates possess a bachelor's degree that includes coursework in the subject area that meets the State's subject matter knowledge standards. In addition, candidates must pass a subject matter test in the area of the license. Most of the students seeking licensure in secondary science education at UMass are enrolled as M. Ed. students in the School of Education. Only a small number complete the licensure requirements as undergraduates. However, a substantial fraction of the licensure students were undergraduates at UMass.

UMass undergraduates or graduates seeking a license for secondary earth science are advised to complete the Earth Science track in the geosciences department that meets the State standards. This track was developed collaboratively with STEP faculty. Students who have completed other tracks usually have to take additional coursework in meteorology, oceanography, and/or astronomy.



As can be seen in this chart, applications to STEP in the area of earth science have ranged from 5 to 11 over the course of 5 years (data from 2001 was not available at the time of this writing). While these numbers are not large, they show a consistent interest in teaching earth science.

Connections between SOE and NSM

There is a more than 10-year history of collaboration between science educators in the School of Education and scientists in the College of Natural Sciences and Mathematics. Many of these collaborative efforts have been projects of the Science, Technology, Engineering and Mathematics Education Institute (STEM Ed Institute) (http://k12s.phast.umass.edu/stem/stem.html). These include STEMTEC, an NSF-funded Collaborative for Excellence in Teacher Education (http://k12s.phast.umass.edu/stemtec); STEMTEC II, a follow-up to STEMTEC, STEM Connections, an NSF-funded GK12 project (http://k12s.phast.umass.edu/connections); Planet Earth, a summer course for teachers supported by NASA (http://k12s.phast.umass.edu/~nasa); and an NSF-funded biocomplexity project with a strong education component (http://www.bio.umass.edu/micro/nusslein/be/index.htm).

The biocomplexity project is one example of a new effort that we are making to provide teachers with the experience of doing science research. This is also part of STEMTEC II and is connected

with the final stage of teacher licensure in Massachusetts (the "professional license"). We are piloting the model this year and expect to involve up to 10 teachers next year.

Challenges

- There is a significant shortage of highly qualified science teachers in our region and in the nation.
- Earth science is not considered to be part of the standard sequence of high school science courses. It is often seen as an elective for college prep students or as a way for lower track students to complete a science requirement. In an early draft of the current MA science frameworks the earth sciences were not included in high school.
- The school subject of "earth science" differs considerably from the academic offerings in the geosciences. One way that we see this in MA is the difficulty that well-prepared geoscience students have in passing the state subject matter test in earth science.

Steve C. Good
Department of Geology & Astronomy
West Chester University

West Chester University (WCU) is the second largest (12,500 students) of the PA State System of Higher Education (SSHE) with a service area that ranges from urban Philadelphia to affluent suburbs to very rural areas. WCU is a regional comprehensive university located about 25 miles west of Philadelphia. About a third of WCU students are in teacher preparation programs, making WCU the largest trainer of teachers in the state of PA. The Department of Geology & Astronomy (G&A) maintains approximately 75 majors subequally divided between the BS and BSEd programs. Graduate employment prospects are excellent (environmental consulting industry is thriving, and regional demographics project school population growth and demand for teachers to continue for foreseeable future).

Recent Challenges
Teacher preparation has multiple challenges, with mandates for change coming from all "stakeholders":
Student and Parent Mandate
The vocationalization of higher education is most strongly pronounced at public colleges & universities. Simply put, our students and their parents want our graduates to get jobs, and that their education should be highly focused on developing those skills needed for the workplace.
SSHE & University Mandates
WCU shares similar challenges to state universities across the nation: legislature mandates to:
increase productivity (increase class size with teaching loads at 24 contact hours per year; elimination of low enrollment programs),
improve accountability:. develop and implement comprehensive assessment plans that employ multiple instruments, and earn external accreditations for programs),
improve efficiency (SSHE Board of Governors have mandated that all Baccalaureate degrees programs be no more than 120 credit hours).
External Mandates
State government has forced changes in PA Department of Education (PDE) teacher preparation

requirements (GPA of 3.0+, identical content requirements for BSEd as BS, post-graduation mentoring, etc.). Federal government has forced changes (NCLB-national report card, teacher certification flexible & accelerated yet "highly qualified", etc.).
SUMMARY: I feel that I am spending more time proving that I am doing my job than actually doing my job.

WCU Department of Geology and Astronomy Response
Our department response was to establish uniform cores to all baccalaureate programs to facilitate career flexibility for our students and to maximize enrollments in our majors courses. A second objective was to establish equitable distribution of required courses among our ten faculty members. The new program is approved and will begin Fall, 2003.
Our department reduced our BSEd program from 135 credits to 120 credits, and our BS program from about 130 credits to 120 credits. This was accomplished by redistributing credits from a mixture of 3 & 4 credit to uniform 3 credits, and in the BS program by reducing the required associated science and math coursework (while strongly advising our students to take more associated science and math courses).
Our department has reduced our number of BS tracks from three (Geology, Environmental Geology, and Earth Systems) to two (Geology & Earth Systems); and BSEd tracks from three (Astronomy, Geology, and Environmental Geology) to one track (Earth & Space Science). We have defined a core of 10 courses that both the BS and BSEd students will complete, which provide the core preparation for ASBOG "Fundamentals of Geology" exam for Professional Geologist Certification. The BS Earth Systems and BSEd programs require an additional 3 courses (Astronomy, Meteorology, Oceanography), since these courses are required as preparation for the Praxis Earth and Space Science Content Knowledge exam and by the PDE teacher preparation standards.
Future Challenges: With our BSEd program at 120 credits, it is efficient. However, it may be too efficient for NCATE (and its required folio that must approved by NSTA ... not to mention when will I have time to produce that folio).

Steve Good's Thoughts on Critical Contributions:
<u>1. Recruiting, mentoring, advising future teachers</u>
Issues and roles of Geosci. Dept:
Career awareness is critical since few students arrive at college wanting to become a geologist or earth science teacher. Most departments rely on their general education science course to recruit majors (more below). Develop coordination with feeder community colleges and school districts in the area (after all many of their teachers will be alumni). Good local earth science teachers can serve as your "farm leagues" and send their talented students to your program. Retention has proven a challenge, with some very capable future geologists driven from the major by math and associated science cognates (where the teaching philosophy is more focused on elimination of the unfit, than welcoming of diverse learning styles/intelligences). I prefer that our department flunk students out of our program on the basis of their lack of knowledge, skills and dispositions to be a geoscientist; and not let the math, chemistry and physics departments identify who may become a geologist/earth science teacher. My undergrad mentor told me that "the best geologist is the person who has seen the most rocks" and so my undergrad program had extensive field experiences. For future teachers these field experiences are in informal and/or informal settings.

Our program strives to provide opportunities for future teachers to interact with middle and high school students and teachers throughout their college academic career.
Facilitate student-student interactions for building community among our majors.
Effective Activities within geoscience depts.
Careers in the Geosciences annual workshop with alumni presenters (teacher, government geologist, consulting geologist) describing their job, salaries, professional development, etc.
Coordinated series of informal and formal field experiences (working with K-12 students).
Geology field trips are crucial tools for recruitment and retention.
We provide a student room and a dept computer lab. These have become centers for community building among our majors

2. Role of Introductory courses in teacher preparation

Issues and roles of Geosci. Dept
Serve as the foundation course to the major and recruitment opportunity.
Collaborative integrated science for future elementary teachers (with mixed success).
Effective Activities within geosci depts.
Our department strives to model best practices in teaching in our gen ed science courses (effective use of technology, hands-on science, cooperative learning, use of controversial topics, shamelessly recruiting using earth science career awareness, fieldtrips where possible)
Majors serve as tutors to Intro Geology students who seek extra help (benefiting all).

3. Research & teaching experiences for future teachers

Issues and roles of Geosci. Dept
Coordinated, longitudinal field experiences are required by PDE and NCATE; that will provide a scaffolding development of skills that will be "field-tested" in the student teaching experience.
Our department also provides opportunities for students to participate in faculty research, a few students have participated in REU programs.
We strongly recommend internships for BS students (to work with state geologic surveys, environmental consulting companies, and these are available to future teachers also
Effective Activities within geosci depts.
Are field components in all education courses (typically 3-6 hours in first 4 education courses, and 18 hours in last two education courses, then 15 weeks of student teaching).
Additional opportunities include working with science Olympiad teams from local school districts, environmental education groups (John Heinz Wildlife Refuge, Valley Forge National Park, Brandywine Valley Association, etc).
Past BSEd students (currently teachers) have participated on paleontology research, and education research (lesson assessors for EarthComm, ESS State Standards project, etc).

4. Links between education and geoscience departments

Issues and roles of Geology Dept
Links and collaboration are critical; however, in times of limited resources the power struggles can be destructive.
Where is the BSEd major in Earth & Space Science housed … in Geoscience Department or in School of Education.
Effective Activities within geosci depts.
University governance structure is critical to defining roles of Geoscience Dept and

Education Dept. Geoscience department faculty should seek opportunities for service on such committees.
Just before my arrival at WCU, the power struggle shifted supervision of secondary student teachers from the school of education to the content area departments.
At WCU, there is currently a conflict between the College of Arts and Science and the School of education that has resulted from the 120 credit mandate from SSHE. We requested the school of education to make a 10% reduction in the Education credits for certification (from 33 to 30 credits), following a 10% credit reduction we had made to the credits from our college. They did not comply, which forced our department to identify one of their courses for elimination (this has caused some political problems).
Future Earth and Space Science teachers are majors in our department. It seems that at most larger and smaller schools, the BSEd majors are placed in the Education school/department relegating them to essentially a "minor" role in the Geoscience Department. Colleagues at research one universities have lamented their number of undergrad majors has declined and that they are under pressure to increase those numbers. Yet when I suggest they take responsibility for the Earth & Space Science teacher preparation program (because while BS enrollments boom and bust with the geology job market, the BSEd job market is constant), they seem distinctly uninterested in training future teachers.
5. Supporting alumni in the teaching profession
Issues and roles of Geosci. Dept
PA Act 48, and NCATE standards require teacher preparation universities to participate and assist our alumni in their first year or two of teaching (induction program).
Alumni teaching in the area are potential candidates for a graduate program, or professional development opportunities for teachers
Alumni teaching in the area can assist by providing field observation placements, and can serve as cooperating teachers.
Effective Activities within geosci depts.
Maintain or establish a graduate program or courses for teachers in your area (teachers need the degrees to progress on their pay scales, and most districts will pay their tuition), but your de3partment will have to teach evenings and summers.
Seek mutually beneficial relationships (science Olympiad, tutoring, etc.)
Maintain contact with alumni teachers in the area who can serve as cooperating teachers. This is one of the greatest benefits to my job ... I may see former BS students once every few years, but I get to work throughout my career with my former students as they become cooperating teachers and we collaborate in the training of future teachers.

David C. Gosselin
Professor, University of Nebraska - Lincoln
Director, Nebraska Earth Systems Education Network (NESEN)

Pre-service Teacher Education and the School of Natural Resources at the University of Nebraska – Lincoln

Introduction to the School of Natural Resources
The School of Natural Resources (SNR) was recently formed through the merger of the School of Natural Resource Sciences, Conservation and Survey Division (consisting of the state geological, water, and soil surveys) and the University of Nebraska-Lincoln Water Center. The new SNR will bring together over 50 faculty and combine programs related to climate, water, fisheries, forestry, geological sciences and survey, remote sensing-GIS, soils, and wildlife. This integration will build on current and existing expertise and promote the concept that to understand our natural resource systems we need to understand the interaction between Earth's physical and biological systems with in which humans exist, interact, and influence. SNR along with several other departments offers five natural resources majors (Environmental Soil Science, Rangeland Ecosystems, Fisheries and Wildlife, Water Science and Environmental Studies-Natural Resources emphasis) within which there are currently 250 students.

Contributions to Earth Science Teacher Preparation
The current portfolio of the SNR contributions to the preparation of Earth Science teachers includes:
NRES 299a. Earth Systems Science of Educators. This course is for students in Teachers College who are intending to be elementary or middle level teachers. In this class, students are introduced to fundamental concepts in the earth sciences and their relationship to the "real world." The specific student outcomes are that students develop scientific process skills, understand and apply basic earth science concepts, and collect and interpret information and data about earth systems. Many of the activities done in class can be used directly in an elementary or middle school classroom. Other activities are designed to challenge the students as learners. All the concepts to which students are exposed can be related to both the K-12 National and Nebraska science education standards. (Gosselin, D.C. and J.L. Macklem-Hurst. 2002. Pre/Post Knowledge Assessment of an Earth Science Course for Elementary/Middle School Education Majors. Journal of Geoscience Education, 50, 169-176.)
Nebraska Earth Systems Education Network (NESEN). Initiated in 1993, NESEN promotes the mutually beneficial interactions between educators and professional scientists and uses multiple strategies to enhance and expand education about the Earth's system in Nebraska and surrounding region. Since its inception, NESEN has grown to over 530 members. Membership includes teachers from 29 other states and Belgium, Nigeria and Greece. NESEN has been primarily supported through grants from NASA, NSF, DOE, National Drought Mitigation Center and the American Geological Institute. (http://nesen.unl.edu)
Accomplishments and Impacts -- The three programs described below highlight some of our experiences and what we have learned about professional development that have implications for both pre-service and in-service K-12 education.
Integrated Research and Education Project. Funded by NSF, nine earth systems research/education teams consisting of a scientist, pre-service educator, and classroom teacher worked together during the summer of 2000. From this project, we learned about perceptions related to scientific inquiry at the K-12 level, the pedagogical practices at a research university, and strategies for developing collaborative teams. (Gosselin, D.C., R.H. Levy, and R.J. Bonnstetter. 2003. Using Earth science research to develop collaboration between scientists at a research university and K-12 educators: Insights for future efforts. Journal of Geoscience Education, 51, 113-120.)
Process-oriented Environmental Change Education Workshops. In collaboration with Dr.

S. Meyer, University of Wisconsin-Green Bay, five workshops have provided professional development for 69 teachers (~ 7,100 students per year potentially impacted). From this project, we learned about the challenges related to creating interdisciplinary curriculum, the importance of curriculum planning time, the use of interpretative exercises for both expanding teacher knowledge and their possible usage in the classroom; and the importance of a flexible, collegial and positive learning environment. (Gosselin, D.C., S. Lowrey, and S.J. Meyer. 2000. Process-oriented Environmental Change Curriculum Development Workshops. Journal of Geoscience Education, 48, 631-635.)

Professional Development Workshops for Earth System Science in the Community (EarthComm). In collaboration with Dr. E. Robeck, Salisbury State University, two professional development workshops were conducted to train teachers to use Earth System Science in the Community (EarthComm). Forty-one teachers were trained over this two-year program. From this project, we learned about the curriculum development process, issues related to the perspectives that educators and scientists have about education, the importance of collaboration and a shared vision, and the identification of the key components required for conducting successful workshops. (Robeck, E.C. and D.C. Gosselin, 2000, EarthComm Teacher Enhancement Manual. American Geological Institute.)

Challenges, Opportunities and Strategies.

The key to developing the Earth Science teacher workforce of the future is developing collaboration between scientists, education faculty and current teachers. Collaboration requires that a working relationship be developed in which the professionals involved choose to accomplish a goal they share (shared goal). Although the word is easily defined, developing collaboration is not easy. For those attending this workshop, we have a shared goal and have made improving the teacher workforce a priority. However, our colleagues/department heads/administrators/students do not have the same priorities or shared goals. One strategy that can be used to modify priorities and goals is to examine the cost relative to the benefits of changing the way we do business. There will be costs. One of these costs will be that people will have to invest time and effort to change and learn to educate students differently. Time will have to be spent communicating with colleagues from both education and science departments. At the university level, a cost will be associated with the development of a reward system that recognizes teaching, educating and collaborating in the same way it does other scholarly activities such as research. Another cost may actually be a trade off between hiring teaching expertise versus research expertise. In contrast to what is commonly believed, scholarly activities related to teaching and research require different skill sets. On the other side of the issue, there are clear benefits. These include opportunities to obtain additional resources from a variety of federal agencies. For example, NSF supports integrated research and educational projects related to understanding Earth systems, ecosystems and biocomplexity. Earth- and Eco-system topics are an integral part of most state science education standards. Teachers often do not have the experience or understanding that is necessary to readily incorporate Earth- and Eco-system topics into their curriculum. Through the development of new courses that use relevant teaching methods, there are significant opportunities to increase our credit hour generation by collaborating with education departments to provide training opportunities for current and future teachers in a way they have never experienced before. Another benefit of improving the way we

teach is that it gives us the opportunity to inform many audiences about a basic premise under which many of us operate, that is, research informs education and education informs research. Without both each will suffer.

Karen Grove
Department of Geosciences
San Francisco State University

Department of Geosciences, San Francisco State University (SFSU)
Strengths in Offerings for Pre-service Teachers

Recruiting, mentoring and advising future teachers
The Geosciences Department maintains a web site with information about the Single Subject Credential in Geosciences, and one faculty member (Dr. John Monteverdi) serves as the Credential Advisor. Dr. Monteverdi keeps the web site updated with current information and advises students about their options.

The role of introductory courses in teacher preparation
Dr. David Dempsey and other Geoscience and Education faculty members generated funding to create two new courses for pre-service teachers. One course, called Planetary Climate Change, was funded by the NASA-NOVA program. It is an interdisciplinary course (geology, meteorology, and oceanography) that investigates the processes that create climate and that cause climate to change. The course counts as an upper-division breadth requirement for students completing single-subject credentials to teach science at the high school level. A second course, called Investigating Air, Sea and Land Interactions, was funded by the NSFCCLI program. It counts as a Physical Science core requirement for the Liberal Studies major, which includes those students completing a multi-subject credential to teach at the elementary or middle school level. This course trains students to develop problem-solving and collaborative learning skills and meets the pre-service K-8 teacher subject matter preparation standards for earth and space sciences.
In most of its introductory-level courses, Geoscience Department faculty aim to acquaint students with the methods of science, to provide opportunities for engagement with real-world date, and to teach with student-centered pedagogies.

Research and teaching experiences for future teachers
Department faculty obtained funding from the NSF-OEDG program to create a new outreach program for local high school teachers and students -- SF-ROCKS (Reaching our to Communities and Kids with Science in San Francisco). Although geared primarily to in-service teachers, SF-ROCKS also provides opportunities for college students from SFSU and the nearby community college who are interested in a teaching career to act as interns in the high schools (see the Intern section of the SF-ROCKS page).

Links between education and geoscience departments
Geoscience faculty have collaborated with faculty in the College of Education to obtain funding for two courses for pre-service teachers and to teach these courses. A third new 1-unit course was developed to train pre-service teachers as peer-facilitators, to support the problem-based learning approached used in the G/M 309 course (see above). The course is co-taught by education and geoscience faculty and provides pre-service teachers with opportunities to engage

in course development and implementation.

Karen Havholm
Department of Geology, University of Wisconsin -- Eau Claire

Background
~10,500 students, primarily undergraduate
Began as a teacher's college, continues to have a strong teacher preparation program
Geology department participates in preparation of elementary/middle level teachers (grades 1-9), and is gearing up to participate in preparation of secondary earth science teachers
Elementary/Middle (1-9) Teacher Preparation
Students are required to take 4 credits each of Life Science, Physical Science and Earth Science. The Earth Science course is specially designed for these students. Course was designed in conjunction with School of Education faculty and in-service teachers.
Features include:
Lab-oriented course
Whole class (50 or 75 students) meet twice a week for 50 minutes. Lab sections (25 maximum) meet once a week for 4 hours. Approximately half of the lab periods in a semester are spent in field experiences. Students learn stratigraphic principles and rock identification in the field. Developing the "Local Geology Story" is a major component of the course.
Mixture of cooperative and individual learning. Students work in groups of 3 or 4 throughout the semester during lab. When groups work well they can be highly synergistic with students doing a lot of teaching of and learning from their peers. Generally one or two groups do not work well, even after juggling to try to match pace, and those students have an experience that is less rich.
Assessment instruments many and varied.
Students have a number of individual writing assignments (local geology report and cross-section, project (teacher observation or children's book), an assignment that asks them to connect course content to a life experience, and a reflective piece. Other homework assignments include things like rock identification exercises, a time line drawn to scale, and exercises in stratigraphic interpretation, weather prediction and
topographic map reading. There is a weekly lab quiz taken as a group, to ensure understanding of the key lab concepts, and there is a group field test. There are also 4 pencil and paper tests taken in class (mostly short answer questions).
Focus on process of science over "facts"
Wherever possible the course emphasizes how we know what we know. For example, plate tectonics is introduced through a historical perspective, showing the kinds of data that prompted ideas of both Continental Drift, early in the 20th century, and Plate Tectonics, later in the 20th century. The focus when learning the layers of the earth is on the evidence for the layers and their composition. The whole field sequence demonstrates how a geologist determines the stratigraphy and geologic history of an area and how a hydrogeologist determines how groundwater interacts with the geology.
Opportunity to observe elementary/middle school earth science classes for class project
Students have to take all of their science courses before they can apply for admission to the school of education. Many of them have had few to no classroom experiences since they have

been in college at the time they take these classes. The opportunity to observe earth science being taught can confirm their desire to become a teacher, or in some cases, make them question their life-plan. This experience also serves to show them why they need to learn about science. "Those 5th graders were learning the same material we are learning" is not an uncommon comment in their reports.

Focus on enriching the perspective of future teachers

In the course of the semester we have daily news items, and course content is related wherever possible to daily life, showing how these topics can relate to their students' lives. The focus on local field geology also opens students eyes to notice the solid earth around them. I try to point out how what they are learning can enrich their teaching even if earth science is not a focus of their curriculum.

Related activities:

I am periodically asked to help students with earth science lesson ideas/materials during later professional experiences, or to give presentations in their classes. I also informally advise students as they seek my input.

Professional development opportunities for in-service teachers provide an ongoing connection with teachers in the area. High-quality teachers are chosen to be in the pool of teachers available for observation. Designing and implementing these professional development opportunities also keep me connected with other science educators in the University.

Challenges:

Maintaining pedagogically appropriate courses in all sciences as staff turns over.

Maintaining an "expensive" course in the face of budget cuts.

Gaining respect of the other scientists in the department for working with teachers.

Developing a secondary earth science teaching program.

Modeling appropriate pedagogy in a college setting (shared classrooms, large class sections, overcoming college student expectations for a 100-level course).

Working with an extremely grade-conscious population (entrance to the School of Ed is highly competitive).

Opportunities

I see working with teachers (pre-service and in-service) as a way to have a greater impact on earth science education.

Strategies for success

In the course, projecting enthusiasm for the subject. Showing students how they might be able to use the content in their own classrooms. Changing how students see their world. In addition, working on boosting their confidence level is critical to ensuring they will be successful in teaching science.

In the larger community, staying connected to the earth science teaching community and contributing expertise in hiring, selection of texts, designing curriculum, and working with in-service teachers.

Jackie Huntoon
Michigan Technological University

Earth and Space Science Teacher Preparation at Michigan Technological University

Michigan Technological University (MTU) recently instituted a teacher training program that allows undergraduates to obtain a degree in Geology (B.S.) and an Earth and Space Science secondary-level teaching credential in only four years. The program is designed for undergraduates who are interested in becoming teachers but wish to maintain strong ties to the academic discipline that most closely matches their primary area of interest. The first group of students to take advantage of this new program graduated during the 1999-2000 academic year. The program, like others leading to teacher certification at MTU, is housed within a content-area department. Pre-service teachers in the program are Geology majors rather than Education majors. This organizational structure ensures that students in the program receive strong content area instruction; it is viewed positively by external review groups.

In Michigan, pre-service teachers must complete coursework that specifically addresses the State's Standards for the Preparation of Teachers in both a teaching major (in this case Earth and Space Science) and a teaching minor. Teaching minors include all disciplines for which teacher certification is available at MTU. The basic program that leads to certification in earth and space science at MTU includes the coursework necessary to satisfy the requirements for a general Science minor. Individual students are encouraged to work with their academic advisor to customize the basic program to meet their own goals. Students can substitute courses and/or complete additional courses leading to teaching minors in Math, Biological Science, Physics, Chemistry, Computer Science, Economics, English, Social Science, or Technology and Design. The basic program is extremely rigorous and requires students to complete a minimum of five credits of field geology plus five credits of field geophysics. Students who are interested in pursuing a second teaching minor are allowed to substitute that coursework for field geophysics. It is hoped that students who complete this program will have great confidence in their abilities as scientists and will pursue graduate study in a geoscience-related field at some point during their career.

At the graduate level, MTU developed a M.S. program in Applied Science Education during 2001. This program is designed to provide in-service teachers from a variety of disciplines with engineering and technology application of math and science. It includes intensive on-site instruction during summer months and on-line courses during the academic year. Teachers in the program are required to complete three 4-credit Applied Science Core courses, three 2-credit Education Core courses, a 3-6 credit Industry or Research Internship, a 2-credit Graduate Research Paper, and 6-9 credits of electives. The first group of teachers graduated from this program in 2003.

Electives in the M.S. program include offerings from the Educator's Science and Mathematics Institute Series (ESMIS). ESMIS courses are offered in the summer and provide teachers with hands-on field- or laboratory-based instruction in several content areas.

MTU also houses the Western Upper Peninsula Center for Science, Mathematics, and Environmental Education, which provides teachers from a five-county area with curriculum support, special programs, field trips, and professional development opportunities.

Carl Katsu
President
NESTA

My organization, the National Earth Science Teachers Association (NESTA), represents about a

thousand K-12 teachers of earth science around the country. Unlike other participants, I gather, we do not take part directly in recruiting future earth science teachers, or play a direct role in the pre-college coursework or preparation of future teachers. However, this past year, as president of NESTA I was able to take part in the National Science Teachers Association (NSTA) task force on the national science standards revision proposal for professional development. Several of our board members and I conferred over the basic coursework and experiences we would recommend for pre-service earth science teachers. I presented our recommendations to the NSTA task force last August. The formal proposal was submitted National Council of Science at the end of the year. Individually, our members do take on student teachers as part of their role of classroom teacher, and in that capacity may advise the pre-service teachers about relevant coursework and field experiences. The role of mentor teacher would be outside of the NESTA organization. I would like to note that from our demographics and those presented in the document Revolution in Earth Science Education, over 80% of our membership are certified to teach earth science; this compares with the national average of less than 50% of those who taught earth science courses this past year were certified to teach earth science. Therefore, our members provide any students teachers they may take on with qualified role models and experienced advice.

NESTA does try to assist existing teachers of earth in science to forge links between their classrooms and the geoscience departments of accessible colleges and universities. We also assist teachers in forging links with professional institutions and government agencies that can provide resources, knowledge, and training in the geosciences. Our officers and members take part in a myriad of conferences, task forces, professional development training, and summer workshops. Our newsletter is used to disseminate information about these opportunities so our members can apply and take advantage of them. The newsletter is also use to report on the information garnered from these sessions, and to provide connections available our members with the institutions that have hosted these sessions, and who are willing to extend their expertise beyond the sessions. Recent examples of opportunities we have publicized are programs and collaborations sponsored by NASA and NOAA, the Jason Project, Earth Scope, Project Atmosphere, the C.O.O.L. Classroom project of Rutgers University, the Research Based Science Education program of the National Optical Astronomers Observatory, the astrophysics programs of Whittier College.

Our members concurred that valuable and successful outreach programs provided them with actual research experience, and with concrete plans and lessons for implementing and communicating what they have learned into their classrooms. Our website URL is http://www.Nestanet.org.

Tom Lindsay
Portland State University

The Geology Department at Portland State University (PSU) takes an active role in the advising and training of K-12 science teachers. We offer Earth and Space Science courses for teachers that are developmentally appropriate at the elementary and middle-school levels. These are designed to enhance both the teachers' understanding of the Earth and Space Sciences and their ability to develop suitable lesson plans for use in the classroom. Teacher preparation takes place at the graduate level at PSU. Students that are trained at Portland State attend the Graduate School of Education's Graduate Teacher Education Program (GTEP) after receiving their

Bachelor's degree.
PSU, located in downtown Portland, is the largest university in Oregon, and has a very diverse student population. The average age of a Geology major is about 27 years. Approximately 90% of this group consists of returning students, many (20-25%) of which already have bachelor's degrees and are changing careers. About 25 to 30% of the students in all general courses at PSU express interest in teaching as a career.
In the College of Liberal Arts and Sciences, students who plan to teach integrated science are advised through the Geology Department. They are required to demonstrate strengths in upper division coursework in at least two fields. Discussions are underway among the Geology, Geography and Environmental Studies Departments, and the Center for Science Education that will increase collaboration among programs and enhance graduate education leading to the Masters of Science in Teaching and an undergraduate major in Science Education.
Continued development of links between the Graduate Teacher Education Program and Geology Department is one of the challenges we face at PSU. Various members of the Geology Department are presently providing support through partnerships with active science teachers but a more active role is envisioned. Our hope is to be become active sounding boards, supporters, resources, collaborators, and co-learners with our elementary, middle-school, and secondary school colleagues.
The future holds great promise in the area of student-teacher-scientist partnerships (STSP). We are one of 5 universities (Colorado State University, University of Northern Colorado, Montana State University, University of Montana, Portland State University) in the National Science Foundation funded Center for Learning and Teaching in the West (CLTW). This consortium is actively researching the factors which account for low participation and achievement in science and mathematics from low socio-economic groups and traditionally under-represented populations. We view Earth Science as a ripe area for the stimulation of student interest and work to marshal resources to this end. One strategy we are investigating involves the remote access of instrumentation (SEM) to help answer student questions using state of the art research techniques.
We know that we don't have all of the answers, but offer advice and assistance to students seeking careers in earth-science education. Through our support, a collegial environment and respect, we actively help Oregon science teachers both in the classroom and out.
Portland State University contact persons:
Tom Lindsay, tcl@pdx.edu
Michael Cummings, cummingsm@pdx.edu

Russanne Low
Science CentrUM
University of Minnesota

Background and Infrastructure of Program Office:
Our mission aims at the Science CentrUM are to provide opportunities for professional development of teachers and classroom support for teachers in K-12 science classrooms. We support University of Minnesota faculty engaged in K-12 science outreach by connecting them to science education and teacher professional development needs throughout the state, assisting them in project development by aligning their products to state and national science standards,

and by promoting faculty-directed K-12 science outreach through our website, list serves, and direct mailing. In addition, we maintain close connections with Minnesota's K-12 community and connect K-12 teachers, schools and districts with University faculty and resources that meet their science education needs. The ultimate objective of the University of Minnesota's Science CentrUM is to contribute to the excellence of science education in Minnesota through programs that involve University faculty and staff, teachers, and students.

Science CentrUM has served as an efficient vehicle to support Earth system science education, pre-service teacher preparation, and in-service teacher professional development. It doesn't make much of an essay, but I have listed some of our activities below.

I. Supporting alumni in the teaching profession

Co-teaching Scientists and Teachers in the Classroom (COSTS)- an innovative professional development program for teachers, enabling educators to acquire topical science content knowledge by working side by side with a scientist for a period of weeks in their own classroom. COSTS implements global change curricula developed by NASA and is sponsored by Global Environmental Strategies, NASA, and the Limnological Research Center, Institute of Technology, University of Minnesota. Current projects include school year, summer, and after school programs at two elementary school sites in St. Paul, and grant money has been secured by the St. Paul school system to include middle school science teachers in the district.

Earth System Science Education Alliance: Science CentrUM was one of first six sites in the nation offering NASA's on-line graduate level course in Earth system science for in-service teachers. Offered in partnership with the College of Continuing Education and the Institute of Technology, there are three versions of the course aligned with grade band standards: K-4, 5-8, 9-12 www.cotf.edu/products/main.html.

GLOBE Training for K-12 teachers A recent grant from Metcouncil provides funding to prepare 5 teachers in 5 schools in the greater metro area to participate in a service-learning project, ground-truthing the Natural Resources Inventory (DNR) using GLOBE protocols. Grant includes funds for postdoctoral scientist support in the participating classrooms on a rotating basis.

Educators of Distinction in Science: Summer Science Educator Academy at the University of Minnesota

This two week, intensive science content-rich professional development program provides 3 graduate credits. This summer the following courses are offered:

FOSS and GLOBE approaches to Elementary science inquiry

Global Change: An Earth system approach

All courses include in-class visits by graduate student scientists, who co-teach with teachers as they implement new knowledge and curricula related to the Earth. Funded by Higher Education Services Office and Global Environmental Strategies.

II. The role of introductory courses in teacher preparation

NASA Opportunities for Visionary Academics: The Institute of Technology, College of Education and Human Development, St. Paul Schools and Science CentrUM are cooperating in the development of an integrated science (Earth and Planetary System Science) course for pre-service teachers, with support from NASA NOVA).

III. Recruiting, mentoring and advising future teachers

Research Explorations for Teachers (REX)- this popular program was first offered in 1993 and is now expanding to meet the need for research and inquiry experience for in-service science teachers. Through contacts in the College of Education, we regularly place pre-service teachers at the Limnological Research Center, Dept. of Geology, for their research science experience

now required for science educator licensure in Minnesota. Placements have included students that are getting certification in chemistry as well as Earth science.

IV. Links between education and geoscience departments

The Department of Science Education and the Department of Geology are collaborating on an NSF proposal targeted at increasing the numbers of certified Earth science teachers (currently 37% in MN; 35-38% nationally teaching Earth science are uncertified in the discipline)

The NASA NOVA course is codeveloped by earth system scientists and science educators from their respective departments at the U of MN.

John Madsen
Department of Geology
University of Delaware

Summary of Earth Science Education Activities

Within the Department of Geology at the University of Delaware, we offer an earth science content course (GEOL 113 – 4 credits (lecture w/lab)) that is required of all elementary education majors. This course, in a rather traditional sense, includes components of physical geology, oceanography, and meteorology. The Department also offers a B.A. degree in Earth Science Education for Secondary Science education majors. This degree program includes 24 credits in education courses (including student teaching), 32 credits in geology and geography courses (e.g., physical geology and geography, mineralogy, surficial processes, field geology, meteorology, conservation of natural resources, applied climatology), and 25 credits of additional science courses (e.g., chemistry, physics, astronomy, evolution, calculus, oceanography).

With funding from the National Science Foundation, we are currently involved in a novel approach to science education for our elementary education majors. The "Science Semester" is a course sequence in which 60 elementary education majors are currently enrolled. This 15-credit semester involves the students taking their earth, life, and physical science content courses and their science teaching methods course in a block sequence (i.e., these are the only courses that the students are taking during this semester). We are using problem-based learning and other inquiry-based approaches to create an integrated science and education methods curriculum. Our goal is to foster integrated understandings of science and pedagogy that future elementary teachers need to effectively use inquiry-based approaches in their classrooms. Traditional subject matter boundaries have been crossed to stress shared themes that teachers must understand to teach standards-based elementary science. The students are working collaboratively on multidisciplinary problem-based learning (PBL) activities that place science concepts in authentic contexts and build learning skills. "Lecture" meetings are large group active learning sessions that help students understand difficult concepts, make connections between class activities, and launch and wrap-up PBL problems. Investigatory labs include activities from elementary science kits as launching points for in-depth investigations that demonstrate the continuity of science concepts and pedagogies across age levels. In the methods course students are critically exploring the theory and practice of elementary science teaching, drawing on their shared experiences of inquiry learning in the science content courses.

Steve Mattox
Grand Valley State University

GVSU is a four-year public institution located 12 miles west of Grand Rapids, Michigan's second largest city. Enrollment is about 20,000. The Geology Department has nine faculty, one full-time staff member, one visiting professors and two part-time adjunct faculty. The department offers an (elementary) Group Science major, a (secondary) Earth Science (ES) major, and a B.S. in Geology. The number of students in each program is 55, 30, and 38, respectively.

1. Recruiting, mentoring and advising future teachers.

Beyond a printed brochure, we do not have a recruiting program to attract students to the ES major. We rely mainly on high quality introductory class to attract students while they take their general education courses. A questionnaire to distribute to our ES students (seeking info on how they selected their major) might be useful. There is a noticeable difference in the mind set of ES and geology majors with the former thinking more about teaching and the latter think more about science. In my opinion the ES students need to be trained to think like scientists as well as be good teachers.

We do not have a formal mentoring program in place. Some students carry out research projects with faculty. I work with 1-2 students per year on specific projects and establish a mentoring relationship that carries through to graduation and beyond.

Students are advised as they progress through their degree requirements.

2. The role of introductory courses in teacher preparation.

All of our ES and Geology majors take physical geology which is also a general education lab course. Nearly all sections are taught by tenured or tenured-track faculty and the goal is to provide an excellent course that attracts majors to our programs. Class size varies from 20 to 120 students. Although we all care about the quality of our teaching, modeling pedagogy methods that would be useful to future teachers is done in some, but not all, classes.

3. Research and teaching experiences for future teachers.

A new course, Earth Science in Secondary Education, has been added to the ES major. Research components have included investigating potential causes of radon anomalies in the county, the 1953 Flint tornado (127 deaths), and the 1904 flood of Grand Rapids (a 100-year flood). Students wrote event-based inquiry lessons for the latter two projects. Although most students enjoyed these projects a murmur of "I'm going into teaching. Why should we be doing research?" could often be heard.

With individual students I have developed inquiry-based lessons along a theme of Geology of Michigan. The students research topics, plan field visits, write (and rewrite) lessons, present their work at state and national science meetings, and use the materials in training sessions for in-service teachers (and in their classrooms).

One student wrote inquiry-based lessons on the volcanoes of the Philippines. We later traveled to the University of the Philippines in Baguio City where he presented his materials to in-service teachers during a week-long workshop.

As part of the new course students are required to visit the classroom of a master earth Science teacher in the area. ES students are required to spend 25 hours in classrooms prior to applying to the School of Education. Many students returned to accrue these hours with the master teacher. Students are all immersed in state science standards and trained to write inquiry-based lessons, commonly on challenging or locally relevant topics ("gaps" in the fossil record, interpretation of

ice core data, or geologic history of Michigan).

4. Links between education and geoscience departments.

All GVSU science education faculty have Ph.D.s in their field and are housed in their respective departments. The education department has two science educators that are dedicated to their graduate program. ES students are trained in content knowledge by geology faculty (plus weather and astronomy by faculty in other departments). Earth Science in Secondary Education helps to bridge the gap between content knowledge and pedagogy. That said, many students comment that their education courses are not relevant to science or that their placements are with teachers weak in science and poorly trained in pedagogy.

Communication between the two departments is good. Representatives from each department meet each semester to discuss common concerns.

At present, ES students are observed by biology faculty during their student teaching.

The Education Department has a Title II grant that places an ES faculty with ES teachers in a poorly performing middle school in urban Grand Rapids.

5. Supporting alumni in the teaching profession.

No formal program is in place to support alumni. We have discussed a listserv to share ideas and resources but no action has been taken.

In Michigan, new in-service teachers are required to take an additional 18 hours of credits in the three years following graduation. Most ES teachers do not want additional education courses. We have developed two new graduate courses (Weather and Climate and Earth Science by Inquiry) specifically for ES teachers. We are also offering summer field trips designed with in-service teachers in mind. This has helped establish a network of ES teachers.

We support one outstanding alumni by developing and providing an AP geology exam to his high school earth science students. About two-thirds of the students pass the exam.

Dr. J. Randy McGinnis
Science Teaching Center
Department of Curriculum & Instruction
University of Maryland, College Park

University of Maryland, College Park
Earth Science Teacher Preparation

I. A Summary of Earth Science Teacher Preparation and Continuous Professional Teacher Education at the University of Maryland (UM)

Undergraduate students at UM who seek to teach earth science at the elementary, middle, or high school levels are enrolled in academic programs that lead to either an undergraduate Education degree in the Department of Curriculum & Instruction (B.S, Maryland State Teacher Certification in grades 1-8) or a double major degree in Education and Geology (B.A, and B.S., Maryland State Teacher Certification grades 7-12). In addition, a second option for undergraduate students seeking teacher certification in secondary schools (grades 7-12) is to enroll in a Fast-Track Bachelor/Master's Program. This is a five-year academic program that allows prospective science teachers to begin work toward Masters in Education (M.Ed) during their undergraduate program, with up to 9 credits counting toward both degrees. For those who hold an undergraduate degree in Earth Science (Geology, Meteorology, Astronomy majors) there

are also additional cohort programs available (Masters Certification Program, Project LINK, Resident Teacher Certificate) that can lead to Maryland certification to teach secondary Earth Science. Finally, the Science Teaching Center in the Department of Curriculum of Instruction offers both masters degrees (M.A, Ed.M) and doctoral degrees (Ed.D, Ph.D) in Science Education for Earth Science Teachers.

Relevant URLs:

UM Teacher Education
UM Department of Curriculum & Instruction
Elementary Education
Secondary Education
Graduate Programs in the Department of Curriculum & Instruction
Science Teaching Center

II. Areas of Strength and Challenges to Our Earth Science Teacher Education Programs

Strengths

UM is recognized nationally for its elementary and secondary teacher preparation programs as well as its graduate programs in education. There is strong collaboration between the College of Education and the Science Colleges in both teacher preparation program development and in matters of pedagogy. Primarily as result of the faculty (content and methods) project activities in the National Science Foundation funded upper elementary/middle level teacher preparation the Maryland Collaborative for Teacher Preparation (MCTP, 1993-2002), prospective earth science teachers take courses in mathematics and science content and in pedagogy taught by faculty who strive to model good teaching practice as defined by the Standards documents in mathematics and science education. In addition, all teacher interns at UM spend significant time in their programs in professional development schools where they are mentored by experienced classroom teachers.

Elementary majors in education must choose a concentration (equivalent to a minor at other institutions) in a discipline. As result, those elementary majors who are preparing specifically to teach middle school science (including Earth Science) are advised to take a concentration in science (selecting courses in Geology, Meteorology, Astronomy and other science fields). UM graduates approximately 50 elementary majors each year with concentrations in science.

Secondary majors who are preparing to teach Earth Science are strongly prepared in both education and in science content. Since 2001, prospective secondary Earth Science teachers must take double majors in Education and in Geology.

As way of supporting the College of Education alumni and other practicing Maryland teachers (including those teaching Earth Science) the UM College of Education is constructing a comprehensive web site of Teacher Professional Resources.

Challenges

Currently, the State of Maryland does not offer a separate certification for the middle school (in which Earth Science is offered). As result, certification is either for grades 1-8 or 7-12. Middle School principals hire prospective Earth Science teachers with either of these certification levels, with the majority those who hold elementary certification since there is a very small pool of newly certified secondary Earth Science teachers from which to draw upon. Therefore, a major challenge for Maryland is how to satisfy the conditions of the No Child Left Behind legislation that apparently calls for all middle school teachers

by 2005 to hold a degree in a discipline and/or successful performance on a content examination.
There is significant challenge in recruiting secondary Earth Science teachers. In the last 2 years no newly certified Earth Science teachers have graduated from the UM program. Presently there are none who have registered to take the senior level methods course in the fall, 2003.

Ellen Metzger
San José State University CA

Earth System Science Teacher Education at San José State University

San José State University's Geology Department has a long-term commitment to Earth system science education, and two of its members have joint appointments in Geology and the Science Education Program of the College of Science. The Department has implemented a multidimensional approach to teacher education that provides pre-service and in-serve educators with a wide array of course options and professional development opportunities.
Our BA Earth Science, Preparation for Teaching is designed for students interested in becoming middle or high school teachers and is approved by the California Commission on Teacher Credentialing as subject matter preparation for a single subject credential with a concentration in geoscience.
The Department has developed "Earth Systems and the Environment", an introductory Earth and space science course that targets pre-service teachers within SJSU's multiple and single subject credential programs. The curriculum satisfies California subject matter competency requirements in the geosciences, and infuses pedagogy into the syllabus. Course activities are designed for teachers' adaptation in their own classrooms.
Through a three-grant from the Institute for Global Environmental Strategies and the Earth System Science Education Alliance (ESSEA), we are offering NASA-approved, on-line graduate courses in Earth System Science for middle and high school teachers. Our ESSEA courses have permanent designations in the SJSU catalog and we will continue to offer them in the future.
The Bay Area Earth Science Institute (BAESI) is a professional development program for future and practicing teachers which was established in 1990 with support from the National Science Foundation, ChevronTexaco, San José State University and a consortium of community partners. The Institute has served 410 teachers in two-to-four week summer workshops and more than 1,000 teachers have participated in BAESI's ongoing weekend workshops and field trips. Teachers may receive inexpensive university credits for their participation in these activities. BAESI sustains a network of Bay Area teachers via its Website and newsletter, and makes classroom materials available through its Earth Science Resource Center.
SJSU's M.A. in Natural Science, a combined effort of the Departments of Geology and Biology and Program in Science Education, is a multidisciplinary graduate program designed for single-subject credential science teachers. It supplies a flexible curriculum customized to individual needs that combines science course work with a science education project. Several BAESI alumni have enhanced their Earth science knowledge

and teaching skills through such projects as field guides to local sites of geological interest and activities-based modules for teaching about earthquakes, rocks and minerals, water quality, and weather.

Ronald Narode
Associate Professor, Math and Science Ed.
Portland State University

Secondary Math and Science Pre-service Graduate Teacher Education:

At the conclusion this year of the five-year NSF grant to the Oregon Collaborative for Excellence
for the Preparation of Teachers [OCEPT] headquartered at PSU, and with the beginning of the NSF Center for Learning and Teaching West [CLTW], there are many new and promising developments in mathematics and science education in the Graduate School of Education in collaboration with the College of Liberal Arts and Sciences. This year marks the first dedicated secondary math and science cohort with 28 prospective math and science teachers in a year-long graduate teacher preparation program. Many of these teachers are completing their MST degrees in mathematics and in the sciences while they are in the cohort. Several have taught courses in the Center for Science Education and University Studies, or in the Mathematics Department and Chemistry Departments. They joined Portland Public School teachers this past summer in the math and science summer academies sponsored by PPS, in conjunction with the professional development supported by CLTW. CLTW Research Coordinator and Diversity Triad Leader, Dalton Miller-Jones, taught "Diversity, Multicultural and Urban Education" to this cohort during summer and fall 2002. The students engaged in community service with minority and poor students throughout Portland as part of their education and reflection as future educators of diverse student populations. They also taught in urban and suburban schools in Portland throughout the academic year.
One of the most important changes in pre-service teacher education at PSU, is the focus on math and science instruction in ALL of the courses that lead toward licensure. This is a departure from the general education courses that must accommodate all disciplines. Within their disciplines, students in the cohort are currently conducting research into the cognitive processes of their students solving math and science problems that examine conceptual understanding and knowledge relevant to instructional design. Several of our students presented their findings at the annual meeting of the Oregon Academy of Science. All of the students will receive training from the national program, Mathematics, Engineering, and Science Achievement [MESA], to become MESA teachers at their schools. They will teach low-income middle school and high school students this summer in MESA and as part of their research toward the Masters of Education degree, and they will lead MESA clubs during the academic year.
The lead CLTW PI at PSU is the current chair of the Geology Department, Michael Cummings. He advises prospective science teachers and decides which courses they need for admission into teacher preparation. He also teaches several courses on topics in Earth Sciences for pre-service teachers. As coPIs on our campus, Dr. Cummings and I work closely on teacher education programs, grant proposals, doctoral committees for science education, professional development coursework for local teachers, etc. He advises the Graduate School of Education on pre-service

teacher preparation, while I assist his faculty in developing research proposals that incorporate educational components.

Monica Ramirez
AIMS Community College

Northern Colorado Community College/University Rural Teacher Preparation Initiative

AIMS Community College, in collaboration with four other community colleges in Colorado and Colorado State University were awarded a three-year NSF grant beginning summer 2001. Although the grant focuses on the recruitment and retention of diverse and rural students into careers in teaching math, science and technology, Aims has focused on chemistry and geoscience education as its major science areas of recruitment.

I. Project Summary

The articulation partnership bolsters the recruitment and retention of diverse and rural students into careers in teaching math, science and technology and strengthens the content and pedagogical skills of prospective and current teachers. The program unites four community colleges serving rural and diverse student populations with the state's land-grant university. Colorado does not have education degrees, so recruitment and retention plans provide community college students with Future Teacher Mentors (FTMs) on each campus to guide them into disciplines at the university preparing teachers in secondary science, math and technology. The emphasis of the program has the community colleges and the university collaborate with three proposed outcomes: (1) to attract and retain greater numbers of students into the targeted teaching areas to serve rural communities; (2) to attract and retain larger numbers of minority students into teaching in the targeted areas; and (3) to improve the preparation and current teaching of math, science, and technology teachers and pre-service providers.

Three specific goals were established for the project to meet the outcomes: (i) recruitment and retention, (ii) collaboration, and (iii) improving science/math/technology/pedagogy preparation. To achieve these goals several strategies were implemented including the improvement of advising/mentoring of community college students through the FTMs. They have created and are advising Future Teacher Clubs, recruiting students, and sharing financial support opportunities. A web site has been be prepared with resources for students and faculty regarding teaching in Colorado, information about the transition from two-year to four-year institutions, and resources on teaching math, science and technology. As the grant is in year two, an annual needs assessment of professional development needs among K-I2 and community college faculty has been prepared to guide activities for a yearly conference and on-line workshops. The first and second annual "Careers in Teaching Science and Mathematics, K-12" conference coordinated by Northern Colorado Community Colleges and the Colorado State University and hosted at Aims has included topics, such as teaching geoscience through field experience, using GIS and GPS in the high school classroom, science lab teaching through distance education, job search for teachers; mock interviews with administrators; etc.

The project is guided by a Steering Committee composed of the four Co- Principal Investigators, the Project Director, a Community College Coordinator and regional K-I2 participants (two superintendents, a principal and a district science coordinator) who meet five times each year to review project activities and support the Project Director. The Project Director is responsible for the day-to-day activities of the project, including the development and management of the web

site, the yearly conference, the on-going professional development plans, and the newsletter. The Community College Coordinator coordinates the work of the community college campuses. The FTMs advise students, work with the Project Director, set up the Future Teacher Clubs, and provide financial support options to students.

Cassandra Runyon (Planetary Geology)
Leslie Sautter (Marine Geology)
Department of Geology, School of Science and Mathematics
College of Charleston

. **Introduction**

The College of Charleston (CofC) is a four-year liberal arts college located in Charleston, SC. Our students come from a variety of backgrounds. The student body now numbers approximately 12,000 students, 70 percent of whom are South Carolinians; other students come from 50 states and 65 foreign countries.

Currently, there is not a formal Earth Science Teacher degree program at the College of Charleston, despite the increased the need for science and mathematics teachers in every county of the state. The college does, however, offer training for Earth Science Teachers at two different levels:

. In-service teaching for post-graduates as part of the Critical Needs Teacher program, for candidates holding a Geology degree;

. Masters degree programs

The School of Education and School of Science and Mathematics together offer a Master's of Education in Science and Mathematics (M.Ed.S.M.). This program is offered for practicing teachers and post-graduates.

The School of Education also offers an M.A.T.

We both work closely with students and faculty in these programs to mentor the graduate students: some of whom are in-service teachers, others are pre-service teachers.

Challenges

The main challenge(s) we have faced has been overcoming the state requirements for teacher certification in Earth Science. Thus, we have placed more emphasis on working with the graduate and in-service teachers. We're now starting to work with the pre-service educators and will continue to work with the local Science Supervisor, State Science Supervisor and State Board of Education as we work through these next steps.

Currently, pre-service teachers are required to take a two-semester sequence in a single lab science (8 hours total), plus an additional semester in a different lab science (4 hours). None of the available introductory courses are geared toward teachers. The science faculty are opposed to such courses, as they feel the curriculum would lack rigor and would "water down" the content.

Recruiting, mentoring and advising future teachers

To date, five students with undergraduate geology and/or environmental geoscience degrees have worked with us for their Master's degrees in Education. These students were recruited directly from our Geology classes for undergraduate majors and worked with both of us on community outreach until they graduated. By then, the teaching 'hook' was set.

Role of introductory courses in teacher preparation
We are working toward developing an alternative series of introductory level courses that maintain academic rigor, but are taught with a hands-on and inquiry-based approach, so that "best practices" are modeled for future teachers. These courses will be open as electives for all students, but will also target pre-service teachers. The School of Education will assist with the development of these courses and will help to fill them with pre-service teachers. These courses would satisfy the additional 4-hour science requirement needed for education majors.
Research and teaching experiences for future teachers
We have both supported future teachers as research assistants and interns with our NASA and NOAA funding. Under this funding, they have assisted with development and implementation of curricula and science education programs. Many have produced theses and educational resource products. Most of this work has been geared toward masters students who will teach at the middle and high school level.
Links between education and geoscience departments
The faculty of the Schools of Education and Science and Mathematics (SSM) work very closely together for the benefit of future science educators, beginning with the support of the Deans of both schools. In addition to the formal education support, the education trainees may also find support at the Charleston County Math & Science Center, located on the CofC campus. This center is funded by the State and provides a Math and Science mentor for educators needing assistance with classroom management, lesson plans and/or curriculum support.
In 1999, we established the Lowcountry Hall of Science and Math at the College of Charleston. This Hall brings the Charleston Math and Science Center (formerly the Hub), the M.Ed. in Science and Math program, the NASASouthEast Regional Clearing House (SERCH) and the NOAA Project Oceanica under one roof to foster collaboration and sharing of resources. Both the Schools of Education and SSM oversee and support the Lowcountry Hall and provide a Director and full-time Assistant Director.
Supporting alumni in the teaching profession
We continue to provide resources and to serve as mentors and colleagues to all of our alums who are now in the teaching profession. We currently employ and collaborate on grants with several.
Strategies:
We will continue to collaborate with the School of Education to develop more funding opportunities and to improve classroom experiences for future science teachers at the College of Charleston.

Randy Sachter
Nederland Elementary School, Boulder CO

As an elementary school teacher, I can only speak to what is happening in Science Education in the elementary school setting. Science has never been a strong subject in the elementary school. This is not limited to Earth Science education, but includes all strands of science. I think this is because few elementary teachers are trained in science. We take general methods courses, which might address the teaching of science, but this doesn't really provide the expertise needed to

teach a content area. Not having the comfort level necessary in this area, elementary teachers often avoid teaching science or choose devote very little time to the subject. In the Boulder Valley School District, there has been an attempt to address this problem. The District purchased FOSS (Full Option Science Systems) that are kits designed to teach a variety of science topics. These kits have greatly helped teachers. They are well designed and developmentally appropriate.

However, in recent years, things have gotten worse. Elementary school science has been on the decline due to legislation around literacy. The demands of documenting student progress in reading and writing as well as preparation for tests leave very little time for anything else. Public schools across the nation tell the same story. Looking more closely at schools that have been successful in raising test scores it has been discovered that they no longer teach science or social studies. The political and monetary pressure of producing higher tests scores has created a lopsided education for our young. In my district, I hear teachers saying they just don't have enough time to even fit a FOSS kit in.

What can we do about this? It would greatly help if teachers just entering the field were better prepared in science through course work and teaching experiences. Teachers need to learn how to integrate science in with literacy. This will help with the "not enough time" problem. In addition, the kit approach has helped many, and continued support through NSF funding would help address the quality issue in developing new kits. Finally, we need to address the political problems. What we need another Sputnik, where the public would demand the teaching of science. Until the teaching of science is valued by the taxpayers, I fear science education will continue to slide.

Mary Savina
Carleton College

Carleton College (a four-year liberal arts college) has a long-standing teacher certification program (grades 5-12) in earth sciences. At Carleton, students seeking earth science certification complete a disciplinary major in geology, several supporting science courses and at least six courses in Educational Studies. They complete their teacher certification with a semester of student teaching, most often in the fall after graduation. (The full description of the teacher education program is on Carleton's web site, along with the specific course requirements for earth science certification) Historically, the Geology Department and Educational Studies Department have collaborated on articulating the goals of the earth science certification program and in identifying the Carleton courses that best match the requirements for licensure in Minnesota.

Because each geology student at Carleton completes a major independent project as part of their major, most students completing the earth science certification program have some research experience.

At any one time, only one or two of the forty or so junior and senior geology majors are in the formal earth science certification program. However, a much larger number of geology (and other) majors are interested in education. At Carleton, many of these students participate in student-led environmental education programs ("Kids for Conservation" for third-grade students in the Northfield public schools, "Prairie and Wood," a summer day camp, and a variety of other activities). After graduation, they get jobs at environmental education centers, in private schools

or through programs like Teach for America. One of the challenges we face is how to help these students self-identify and receive the kind of mentoring and curricular support they need in their undergraduate years. Another challenge is increasing the number of formal and informal opportunities available for these students both to teach and to participate in campus conversations about environmental education. Science departments and the Environmental and Technology Studies program are cooperating in setting up these opportunities.
A second group that needs special support is students interested in elementary education. Although Carleton does not offer elementary education certification, about 10-15 students in the humanities and social sciences graduate each year and go on to elementary school teaching, in private schools and through Teach for America. Many later return to school for a masters' degree and eventual certification. An ad-hoc group of science and mathematics faculty has begun discussing ways to encourage these students to target their undergraduate math and science courses to prepare themselves optimally for elementary education. For this group of students, Carleton's introductory science classes, including introductory geology, are particularly important: virtually all of these classes are taught using active learning strategies and have strong project-based assignments and labs.
Historically, Carleton geology faculty have played a strong role on the national level in science education initiatives through AAAS, the NAS, AGU, PKAL and other organizations. We expect these relationships to continue. Locally, we partner with the Cannon River Watershed Partnership to offer in-service courses for current teachers and with local nature centers to provide practical experience for students.

Nate Shotwell
Mills E. Goodwin High School, Richmond VA

As a third year high school Earth Science teacher I come to the table with a different background and interpretation on the questions at hand. I will reflect on the questions at hand from the perspective of a practicing teacher first with respect to recruiting new teachers and second with respect to improving teacher retention and support.
It is important to note that future Earth Science teachers will likely fall into one of four general categories.
. Individuals who know they want to teach when they arrive at college and come to the realization that geoscience is their field of choice.
. Individuals who enter college with a desire to study the geosciences and while in college realize that that they would like to work in the field of education.
. Individuals who graduate with a degree in the geosciences and upon graduating realize that they would like to enter the field of education.
. Individuals who are certified to teach other science but did not study the geosciences in college, however, because of the critical shortage of teachers in the geoscience field are asked to teach out of their area of expertise to accommodate the need.

Teacher Recruitment

Geoscience educators in the community of higher education can make the most measurable contributions to the number of qualified K-12 geoscience educators by directing their efforts at the first two categories of college students.
In order to recruit teacher candidates it is imperative that geoscience departments devote their

strongest faculty members to teaching introductory level classes. This ensures that all students will have a positive first impression of the geosciences and be more likely to enroll in additional courses. Introductory classes should avoid rote memorization whenever possible and focus on real world issues in order to engage students at a higher level of thinking.

Motivated college students who know they want to teach will also take advantage of, and thus be attracted to departments which offer them opportunities to participate in the teaching process early and often. Geoscience departments should strive offer interested students the opportunity to assist in introductory labs as teaching assistants. Additionally, while it does require significant planning as well as a budget, strong faculty guidance, and significant student man-hours the implementation of an outreach program in partnership with local elementary and high schools provides a wonderful opportunity for students to develop and practice teaching skills. William and Mary has a strong program in place called Geology on Wheels that does just this.

One of the strands we have been asked to reflect on is the role of student research in preparing future teachers. I do consider the Geology senior project I wrote as an undergraduate as invaluable to me as an individual and scientist (a research thesis approximately 15 pages of original research). I also completed a senior project through my college's education department (an original thematic unit in my field of study). I must say that as a teacher I have not had significant opportunity to reflect on or use my research experience in my classroom, while the unit I developed has been quite useful to me (though it lacks scientific rigor). Geoscience departments that require undergraduate research or senior projects should strongly consider offering students enrolled in the college's teacher preparatory program the opportunity to complete an alternative, equally rigorous project designed to develop units, labs, or technology projects that they will be able to use in the classroom. The completion of such a project under the supervision of the geoscience faculty would ensure a modern scientific foundation and scientific rigor that exceeds the level which many education departments require. This would ensure that sound pedagogical ideas and strong scientific rigor are making their ways into high school classrooms together.

Teacher Retention and Support

As a third year teacher who works very close to the college from which I graduated I have become quite dependent on William and Mary for support and help. Supporting practicing teachers is just as important as recruiting new teachers. Geoscience department members there have been very helpful to me in a huge variety of ways. They have been open to answering questions that have come up in my class that I don't know the answers to and haven't been able to find on my own. I have been included in professional conferences, online discussions, and email list-serves. I have been allowed to borrow lab supplies from the department that are not traditionally available to high school teachers. I have also had the opportunity to teach using the W&M Virginia Geology site to teach regional geology, a concept that is not covered in any high school textbook but state education standards mandate we cover. The W&M Geoscience department has also actively worked with other departments to offer workshops and seminars to local high school science teachers connecting them to modern research and providing them activities and resources for use in their own classroom.

Online databases of classroom activities are readily available but are often under utilized. Teachers have limited time and tend to use what is familiar to them, encouraging use of such databases might best be accomplished by encouraging teacher submission to such databases.

One other resource that is more difficult to line up but could prove very successful is the creation of a local "speaker's bureau". Faculty members, practicing geoscience professionals, or students

who have conducted interesting research could be included on such a list. These individuals could speak to interested classes in order to provide a concrete connection to the real world for high school students.

William Slattery
Associate Professor, Department of Geological Sciences
Wright State University

Proficiency tests

In 1994 the Ohio State Legislature charged the Ohio Department of Education to develop proficiency tests for K-12 students in Language Arts, Mathematics, Social Studies and Science. This was a difficult task, as each of Ohio's 611 school districts is under local control, each with their own local curriculum. The Ohio Department of Education cut the Gordian knot by using the newly developed national science education standards as a framework to develop the Ohio Proficiency Tests. This decision thrust Earth/Space science into the curriculum at every grade level in Ohio's K-12 schools. This presented challenges to school districts and individual classroom teachers, because Earth/Space science was never a required content area for most teacher education programs in the state. They faced the challenge of preparing their students for a high-stakes test in an area that they were not well prepared to teach.
Wright State University responded to these challenges by recruiting science educators in all science content areas to serve with joint appointments in the Colleges of Science and Mathematics and Education /Human Services. These newly hired science educators were charged with developing new courses in inquiry-based science, including Earth/Space science. These new science courses were housed within science departments rather than the College of Education and Human Services. This had a profound impact on enrollment figures for the Department of Geological Sciences because the development of this course and the influx of undergraduate education students into the department coincided with a general downturn in the "traditional" undergraduate and graduate student enrollment in the Department of Geological Sciences. The Department of Geological Sciences developed a course required of and exclusively for pre-service teachers seeking licensure in Early (PK-3) and Middle Childhood education (4-8) in Earth/Space science. This course blended these components and sought to build the students conceptual understandings and content specific pedagogy through cooperative learning experiences in the classroom and field-based experiences (Slattery, 1996). An additional required course in Earth Systems science has recently been added for Middle Childhood (grades 4-8) pre-service teachers seeking a science concentration. This web-enhanced course also uses the national science education standards as a content and pedagogical framework. Strengthening pre-service teacher education in Earth/Space science was only one facet of the departmental effort. Continued connection with pre-service teachers after graduation has strengthened science education as a whole. Newly minted teachers, armed with knowledge of inquiry-based science, and with a few years experience in the classroom now serve as mentors for other student teachers. They have played a significant role in other components of departmental science education efforts, such as supporting in-service teachers with Master's programs and other professional development opportunities. The Master of Science in Teaching (Earth Science) program (Slattery and Brame, 2003) is a hybrid of content and education. Thirty-three quarter

hours of coursework, including an independently developed research project along a spectrum of (for lack of a better term) "pure" scientific research and classroom action education research are required. In addition, participants may take up to 12 quarter hours of coursework in the Colleges of Education /Human Services. Over 100 in-service teachers have graduated from this program in the past several years. Our continued outreach efforts to other K-12 teachers for shorter term professional development activities and for continued recruitment into the Master's program have been built on the foundation of pre-service teacher Earth/Space science education.

Slattery, William (1996). A Course to Train Pre-service Elementary Teachers the Content and Process of Science. *Journal of Geological Education*, v.44, n.3, pp. 259-261.

Slattery, William, Brame, Roderic (in press for May, 2003) Supporting the Standards: A Master's Degree Program for K-12 Teacher Professional Development. *Journal of Geoscience Education*

Catherine L. Summa
Geoscience Department
Winona State University

The Geoscience Department at Winona State University (WSU) is a four-person department offering BS degrees in Geology, Environmental Geoscience and Earth Science Teaching. Roughly 20% of our majors are in the Earth Science teaching program. In MN school districts, most earth science is taught at the 8th grade level. The Earth Science teaching program prepares students for MN licensure at grades 5-12; preparation in grades 5-8 focuses on general science by state requirement and grades 9-12 focuses on preparation in the specialty field. In addition to preparing students for 5-12 licensure, we assist in the preparation of elementary education majors, particularly those choosing to specialize in the K-6 with middle-school science licensure. Students in our secondary earth science teaching program are required to complete a research project. Part of their project focuses on scientific discovery and part of their project focuses on translating that activity into inquiry-based classroom curriculum. Each student develops at least one, and usually several, lessons that build from the concepts they worked with in their research. Most lessons are designed for an eighth grade earth science class. Past projects have included activities designed to help students understand how karst develops, exploring the evolution of glacial landscapes, developing technology rich meteorology laboratory exercises, and understanding how to sample stream bedload and discharge. When possible, we encourage students to try the lessons they develop in a classroom situation. Depending on the student and the lesson, this may take place in a local middle school class, during a field experience required during one of their education courses, or in one of our introductory-level laboratory sections.

In addition to a research project, each secondary earth science teaching major is required to participate in several out-of-class activities. These are designed to provide the student opportunities that mimic the experiences they are likely to encounter in their future teaching assignments. Students must: judge a science fair and/or mentor a student completing a science fair project; host a (earth-science related) visit by a K-4 student group; host a visit by a 5-12 student group; and serve as a peer tutor or departmental teaching assistant for at least one semester during their undergraduate experience (students are paid an hourly wage for this work, although many choose to volunteer their time). If a student opts to TA an intro-level laboratory

course, we make every effort to allow the student to "teach" the laboratory (under faculty supervision). Our graduates often comment that these out-of-class requirements were some of the more valuable experiences of their preparation. They particularly enjoy the opportunities to interact with K-12 students doing science, which is not always possible as part of their field experiences associated with their education courses.

Most of my work at WSU has been focused on developing new courses for all elementary education majors. I work with a faculty team with expertise in each of the natural science content areas and with colleagues from the Education Department. We are developing a three-semester sequence of courses that will be required of all elementary education majors. The sequence of courses is being developed around a learning cycle model with the intent of modeling effective pedagogies for teaching science in the elementary classroom and to build the pedagogical content knowledge of our pre-service teachers. Research shows clearly that teachers tend to teach the way they were taught, thus, we believe it critical to model best practice for pre-service elementary teachers at this important juncture of their careers. Our goal is to develop a sequence of courses that provides all pre-service elementary education majors with a rigorous, standards-based introduction to the scientific concepts they are most likely to teach in their future elementary classrooms. In addition to delivering scientific content, we want our students to develop skills in pedagogy; thus, a second goal is to increase our students' ability to teach science effectively in their future classrooms.

The overall focus of our three-course sequence will be "science in your community," with the broad goal of teaching pre-service students science content in a context that will enable them to develop similar activities for their future classroom.

The first course, which will be offered for the first time next fall semester, introduces students to the "exploration" phase of the learning cycle, via an integrated field-based study of water. Since water is integral to life on this planet, we developed this course around a topic that would be accessible to all future teachers in their community, thus ensuring that our pre-service teachers would be able to bring their college content to bear in their future teaching assignments, wherever they find themselves. The second course will be a modification of the existing methods course, and will reflect the "term-introduction/ invention" phase of the learning cycle. The second course will focus on the process of scientific inquiry. In this modified methods course, students will study how scientific ideas are developed, the nature of scientific experimentation, and how to bring these concepts to the P-8 classroom. The final course in the sequence will reflect the "expansion/application" phase of the learning cycle; students will explore and research different scientific questions pertinent to the community. Our goal is to have our students investigate environmental issues with strong socio-political concerns. Potential topics include the issues surrounding siting new factory farms; the impact of varying the volume of water released at local dams on both the landscape and on wildlife communities; the impact of dredging local lakes and rivers; the impact of development on local wetland communities; and the impacts of increasing urbanization resulting from increased commercial and corporate development in the community.

Our primary goal in designing our new curriculum around "science in your community" is to help our pre-service teachers learn science in a context that will be easily portable to their future classroom. The first course in our sequence is titled "Earth -- the Water Planet." Since every community must wrestle with issues of water supply and management, we felt it made good sense to focus the first course in the sequence on this topic. All students, whether they are fully aware of it or not, are already familiar with many of the scientific issues related to water. The

same will be true for our pre-service teachers once they find themselves in their future classrooms—their students, too, will have some familiarity with water. Because students learn best when they can connect new concepts to preexisting knowledge and experience, this approach should provide all students a framework upon which to situate and connect their new (scientific) understanding to their daily lives.

We plan to include secondary teaching majors in this program by having them serve as teaching assistants for these classes. In this way, we believe that our secondary students will have the opportunities to become immersed in a standards-based approach to science, and will be challenged to integrate their science content and relate biology, chemistry, and physics to their work in earth science. Although perhaps not the ideal forum for meeting the unique needs of pre-service secondary majors, the relatively small numbers of secondary science-teaching majors, especially as compared to elementary education majors, makes it difficult to obtain administrative support for the development of classes specifically designed for secondary majors. It is my hope that by developing a strong elementary science education program, we will be able to find the resources to build discrete opportunities for students in our secondary program.

Richard Yuretich
University of Massachusetts

My experience is that promoting only Earth-Science education at the Departmental level is not an effective strategy. Most faculty members are already extensively committed to research and education at the undergraduate and graduate levels. A specific effort to promote Earth Science teaching, while viewed as a worthwhile endeavor by almost all my colleagues, does not stay on the radar screen for very long. At UMass-Amherst, pre-service teachers are not usually identified as a distinct population from other students. Massachusetts requires that students intending to become teachers major in a liberal-arts or science subject, although they may declare a secondary major in Education. Very few students interested in teaching at the elementary level consider a major in the Earth Sciences, or any science for that matter. For those interested in middle- or high-school teaching, our Department has a separate track in the Geology major that steers students to the content courses required for licensure, and provides a greater degree of flexibility for completing the Education courses they need. There are no separate Geology or Earth Science courses designed exclusively for teachers; they enroll in the same introductory courses as the general student population.

Although there is no concerted Departmental effort to systematically reach out to pre-service teachers, many faculty members have established links on their own initiative. In some of the large introductory courses, we identify prospective teachers and give them peer-teaching opportunities in the course. In a similar manner we provide opportunities for prospective teachers in the Geology major to tutor other students. Some faculty members also make research opportunities available to recent teachers, either to work in the laboratory or to help develop instructional materials based upon the research.

Collaborative efforts among science departments and with the School of Education have been more effective. We were involved in a University-wide initiative to improve the preparation of teachers through a NSF Collaborative for Excellence in Teacher Preparation), which has left several permanent features on the landscape:

. Explicit incorporation of active and collaborative learning strategies into undergraduate

courses, especially introductory courses likely to have a high proportion of pre-service teachers.
. Development of a course "Exploring Science and Mathematics Teachers" co-taught by science and education faculty members, to give interested science majors some introduction to principles and practices of teaching and learning.
. Maintenance of a Science, Technology, Engineering, and Mathematics Education Institute to coordinate opportunities for students interested in teaching, and to foster faculty participation.
More recently, we have been part of STEM Connections, a NSF GK-12 initiative to place science graduate students in the K12 classroom). We have two Geoscience students actively participating and others planning to do so in the next year. Active collaboration among science, engineering, and education also led to a successful research proposal that uses in-service teachers as research assistants. In addition to working with one of the project's scientists or engineers, these teacher associates also participate in a research seminar, and they will design a unit plan around their research experience. For several years we had program for both in-service and pre-service teachers entitled "Planet Earth", which use environmental topics as a catalyst to pursue scientific investigations.. Description of each of these initiatives can be found online.
There are several challenges that must be addressed to sustain these efforts. In the first place, students must be assured that teaching is a viable career alternative. In the current political climate of high-stakes testing and economic disincentives, it is not an easy argument to make. Likewise, faculty need to be assured that there is a positive payoff for making this part of their agenda, specifically, campus leaders need to emphasize that such efforts are part of the institutional goals. Communication between the science and education faculty is critical, so that the each can be informed and updated of initiatives or improvement in the other field.