It's Time to Stand Up for Earth Science

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ABSTRACT

This commentary paper focuses upon the loss of respect for Earth Sciences on the part of many school districts across the United States. Too many Earth Science teachers are uncertified to teach Earth Science, or hold certificates to teach the subject merely because they took a test. The Earth Sciences have faced this problem for many years (Nuhfer, 1990). In 1996, the *National Science Education Standards* (National Resource Council) put Earth Science on equal footing with both the life and physical sciences, but after middle school, many high school students do not even have a chance to take an Earth Science course because their schools do not deem Earth Science as worthy or even as a necessary science. This is echoed by many colleges and universities when they do not accept Earth Science as a science unit for entrance. This must change! With the *Next Generation Science Standards* (Achieve, 2012) on the horizon, educators from kindergarten to the university level must make a strategic effort to put Earth Science back up upon a pedestal with sciences such as biology, chemistry, and physics—not just in a few states, but in all states! © *2012 National Association of Geoscience Teachers*. [DOI: 10.5408/11-264.1]

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INTRODUCTION

Not too many years ago when I was teaching in a large urban district, my principal told me that one of my senior students was not accepted to a major university to study engineering because he had taken Earth Science as one of his four science courses during his high school career. The principal asked me to help convince university officials that my Earth Science class was not remedial, but was as rigorous as courses in Biology, Chemistry, and Physics. Although it took about six weeks into the summer, I finally was able to convince the university that my course was indeed on a par with the other three courses. How? I showed them my curriculum, the class objectives, and the lab activities that went into completing my course. Moreover, to appease the university officials, the principal and the school district decided to change the name of my course to "Advance Earth Science." By doing this, we were able to change the student's transcript, and subsequently he was accepted into the university's engineering program, with a full scholarship no less. I kept asking myself: "Why were university officials eager to accept Advance Earth Science, but not Earth Science?"

The answer has to do with respect. Somehow, in the past few decades, Earth Science has become a subject that administrators and educators deem to be a remedial science class. A recent report funded by the U.S. Department of Commerce, the National Oceanic and Atmospheric Administration (NOAA), and their Office of Education stated that "[w]hile Earth science concepts are taught throughout K–12 education, these learning experiences are often considered of less rigor and substance than other domains of science" (Hoffman and Barstow, 2007, p. 5). What many consider to be simple and easy for students to learn in fact requires careful planning of the content and instructional activities by the teacher and knowledge of how their students' learn this content. This planning changes from class to class and from year to year. This is particularly true at the college and high school levels. In many U.S. high schools, counselors put students into Earth Science classes if the students are performing at a low academic level or if they need an "easy" credit for graduation. As a high school science teacher and curriculum writer for over twenty years, I have seen school districts not offer Earth Science because of its remedial status. They instead offer Advanced Placement (AP) courses in biology and chemistry or other advanced-level courses to their students rather than the AP geology class that has been available since early 2000. By having high schools do this, many students see the Earth Sciences as not important.

WHAT'S WRONG WITH EARTH SCIENCE?

In 1990, Edward Nuhfer wrote an article in the *Journal of Geological Education* entitled, "Anyone Can Teach Earth Science!" (Nuhfer, 1990). He based his article on the fact that in 1990, over 40% of Earth Science teachers were not qualified. Fifteen years later in 2005, the National Center for Educational Statistics (NCES) reported the number of unqualified Earth Science teachers to be over 50%. When compared to teachers in other sciences taught on the secondary level—biology, chemistry, and physics—fewer than 15% were unqualified (NCES, 2005). With this increasingly dreadful trend in science education, it is no wonder that even today some people state, "Anyone Can Teach Earth Science!" Orion and Ault (2007, p. 679) stated that "the ability of educators to establish Earth Science as a sustainable course of study is highly dependent on the ability of science teachers to overcome many barriers, including their own lack of background and the persistently low stature of the field." Some states have even created various ways to certify science teachers in order to decrease the number who are considered unqualified when teaching Earth Science at the secondary level.

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For example, many of the practicing secondary (7–12) Earth Science teachers in the state of Missouri are currently teaching with a unified certification. This teaching certificate was created to address shortages found on the secondary level in various science disciplines over the last fifteen years. A unified certificate allows an individual to teach all science disciplines on the secondary level. Most of those with unified certificates have specialized in one science discipline, primarily biology. As undergraduates, these teachers usually take from one to three courses in the Earth Sciences, depending on where they received their undergraduate degree, in order to obtain their unified teaching certificate in science. It is these courses that serve as the teacher's primary source of their content knowledge of the subject and serve as their model for teaching Earth Science.

With this in mind, Missouri's Department of Elementary and Secondary Education (DESE) reported that there are over 1,100 teachers able to teach Earth Science on the secondary (7–12) level (American Geological Institute [AGI], 2010). Diane Grubbs, former science coordinator of the Ferguson-Florissant School District in the St. Louis area, indicated that "there are only about 30 of those teachers that actually have an undergraduate degree in the Earth Sciences" (personal communication, January 13, 2007). With school districts experiencing difficulties in finding teachers with certification in the Earth Sciences, many Missouri school districts have dropped Earth Science courses from their curriculum, even though over 45% of the state content standards are related to the fields of Earth and environmental sciences (DESE, 2008). "The production of Earth Science teachers, unlike biology teachers, has never reached full capacity, which has likely contributed to the lesser presence of Earth and Space Science in U.S. high schools today" (Lewis, 2008, p. 445).

As of 2006, AGI identified that there were 12,695 Earth Science teachers in the U.S. Currently, the state of New York ranks first in number of Earth Science teachers with well over one-fifth of the total count (Passow, 2008). Why? The state of New York puts an emphasis on Earth Science education with students being tested on the subject at the fourth and eighth grade levels and as part of their Regents Science program on the high school level. More than 150,000 students each year take the Regents exam in Earth Science (Passow, 2008). With such an emphasis on Earth Science education, many of the teachers certified in this field sometimes will leave their home state to teach in New York. This leaves many states offering alternative ways for teachers to get certified in Earth Science, such as the unified science degree or merely by taking the Praxis exam.

Recently, Lewis and Baker (2010) called for more researchers in science education to focus on the geosciences: "We argue that such research studies (Geosciences) are necessary to inform science education policy and advance scientific literacy" (p.121). In fact, when one studies research in the Earth Sciences, a person finds limited resources to work from, which may be one of the reasons why there is a lack of support for the subject.

EARTH SCIENCE AND ITS IMPORTANCE

Could it be that Americans do not understand what Earth Science is and how essential it is in understanding our world? AGI states, "Earth science has been part of the curriculum in American schools for more than 100 years" (2004, p. 5). So what is Earth Science? According to Smith (2004):

> The study of Earth Science provides the foundation for an understanding of the Earth, its processes, its resources, and its environment. Earth Science is the study of our planet in its entirety, how its lithosphere, atmosphere, hydrosphere, and biosphere work together as systems and how they affect each other and us. Earth Science integrates biology, chemistry, physics, and mathematics to an understanding of the Earth around us. Earth and Space Science is a laboratory and activity-oriented course, which lends itself well to helping students to develop knowledge and abilities about inquiry and the nature of science. (p. 31)

It is vital for the citizens of the world to understand the relationship between Earth's systems and humanity. This includes the impact of natural processes on human health and safety, the dependence of all people on Earth's resources, and the impact of human activities on global climate processes (AGI, 2004). The result of persistent misconceptions about scientific phenomena is an ill-informed citizenry and a reduced possibility of appropriate preventive actions by these citizens against future problems (Boyes et al., 1995). These problems in the near future could include the loss of sustainable farmland and fresh water for the world's growing population as well as global climate change. "The study of Earth Science can provide an integrated, interdisciplinary approach that meaningfully connects chemistry, physics, and biology to allow students to better understand our complex planet" (Metz, 2008, p.8).

The *National Science Education Standards* (National Research Council [NRC], 1996), *Scope, Sequence, and Coordination: A Framework for High School Science Education* (National Science Teachers Association, 1996), *AAAS Benchmarks for Science Literacy* (AAAS, 1993), and now *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC, 2012) have emphasized the critical role Earth Sciences play in the development of an individual's scientific literacy. The *Framework for K–12 Science Education*, which provides the scaffolding for the *Next Generation Science Standards* (Achieve, 2012), continues to treat the Earth Sciences equally with life and physical sciences in regard to scientific literacy. This point is not only for students to understand, but for teachers as well. It is now time for Earth Science to stand up and be recognized as an essential science for all Americans to take in school. Therefore, Earth Science curriculum needs to undergo a major transition in the way Earth Science content is presented, such as using Earth System Science instead of the traditional way by breaking the subject into four separate sciences—Geology, Oceanography, Astronomy, and Meteorology.

EARTH SYSTEM SCIENCE

Before the release of *Science for All Americans* (American Association for the Advancement of Science [AAAS], 1989), a group of educators and scientists met to discuss reforming Earth Science education in the U.S. This group was established by the NASA Advisory Council in 1983 and was known as the Earth System Science Committee (ESSC),

which was headed by Francis Bretherton. In 1988, the ESSC published a report called *Earth System Science: A Program for Global Change*. This report, also known as the *Bretherton Report*, first used the term, "Earth System Science" (ESSC, 1988). The ESSC recognized that the Earth is a dynamic planet and that nothing on Earth happens in isolation. "The goal of Earth System Science is to obtain a scientific understanding of the entire Earth system on a global scale by describing how its component parts and their interactions have evolved, how they function, and how they may be expected to continue to evolve on all time scales" (ESSC, 1988, p. 26). ESSC (1998) also identified three reasons to teach Earth System Science (ESS): to reap the practical benefits of understanding the Earth and interactions, to understand global changes, and to understand the Earth as a planet.

Even the *Benchmarks for Science Literacy* (AAAS, 1993) discussed ESS as one of the premises in teaching all the sciences. Mayer (1995) considers the *Benchmarks* can be "an important tool for Earth systems educators as they locate more specific information for the construction of curricular models for their particular school districts" (p. 385). In 2007, Environmental Literacy Council (ELC), along with the National Science Teachers Association (NSTA), revisited this topic and stated, "An advantage of systems thinking—whether of biological, mechanical, astronomical, or any other entity—is that one can isolate parts for study (or action) while keeping in mind that they are not entirely independent" (p. 5).

We must remember as educators that the key to ESS is the term "system." A system is the relationship between interdependent parts within a well-defined area. For ESS, those parts are called "spheres," of which there are four:

- the lithosphere, which contains all of the cold, hard, solid rock of the planet's crust (surface), the hot semi-solid rock that lies underneath the crust, the hot liquid rock near the center of the planet, and the solid iron core (center) of the planet;
- the hydrosphere, which contains all of the planet's solid, liquid, and gaseous water;
- the biosphere, which contains all of the planet's living organisms;
- and the atmosphere, which contains all of the planet's air. (Wheeling Jesuit University, 2004)

ESS teachers can focus on both naturally occurring and manmade events and distinguish the cause and effect changes that happen among the spheres. These changes do not happen in isolation within each sphere, but usually have an effect on each of the other spheres. By building on these interactions, teachers can instruct students on how one sphere relies upon the others. *A Framework for K–12 Science Education* (NRC, 2012) recently reinforces this position by stating:

> Earth consists of a set of systems—atmosphere, hydrosphere, geosphere, and biosphere—that are intricately interconnected. . . . Understanding the different processes that cause Earth to change over time (in a sense, how it "works") therefore requires knowledge of the multiple systems' interconnections and feedbacks. (p. 170–171)

Moreover, "different aspects of the Earth system (subsystems within it) interact to create adverse and/or beneficial impacts on the environment" (ELC and NSTA, 2007; p. 6). In the past couple of years, the U.S. and the world have witnessed many devastating disasters that teachers can use to embrace the teaching strategies of ESS. These include, for example, the disastrous oil spill in the Gulf of Mexico, the Japan earthquake and subsequent tsunami, and the Joplin, Missouri tornado. These terrible disasters allow teachers to demonstrate to students the interdependence of each of the Earth's spheres, the impact that they have upon one another, and the relational effects on the Earth in future decades, but only if teachers start teaching with a broader perspective.

So what is the problem, if all of the policy documents and science educators are in agreement about teaching ESS instead of Earth Science? The first problem is the availability of proper textbooks and resources for teachers. There are some textbooks currently promoting ESS, but most textbook publishers still promote Earth Science textbooks that isolate the teaching of Earth Science into separate units. The second problem is how teacher education programs are preparing future Earth Science educators. Most college and university programs currently do not offer content courses or science methods courses that emphasize ESS.

CLOSING

In 1991, AGI and their affiliate, the National Center for Earth Science Education (NCESE) published a guide, *Earth Science Education for the 21st Century: A Planning Guide*, which developed a framework to help plan and implement K–12 Earth Science education programs. The document focused on four areas of concern: Goals for Earth Science Education, Essential Concepts in Earth Science, Teaching Earth Science, and Implementation of Earth Science in Grades K–12. Recently, AGI (2011) published another report, *Advancing Earth Science: K–12 Earth System Science Education Summit*, in which Earth Science educators and other related agencies were once again voicing the same concerns that were brought to our attention over twenty years ago. Of the ten "Big Ideas" agreed upon by the participants at the summit, I believe that the first idea that needs to be addressed is number six: "A nationwide campaign is needed to encourage institutions of higher learning to accept ESS high school courses as laboratory science courses" (p. 2). This challenge comes at a time when many universities and colleges are cutting back educational programs such as the Earth Sciences due to costs and the lack of students majoring in those programs. Persuading higher education to finally accept ESS as a laboratory science will open doors to conquering other problems facing the geoscience community in promoting their discipline.

It seems that we, the geoscience community, know what the problems are, but we cannot seem to break this cycle of disrespect from our own educational community. We can write all kinds of commentaries about the problem, attend numerous meetings, have literacy guides written explaining the essential ideas of ESS such as *Climate Literacy: The Essential Principles of Climate Sciences* (U.S. Climate Change Science Program, 2009), *Earth Science Literacy Principles: The Big Ideas and Supporting Concepts of Earth Science* (Earth Science Literacy Initiative, 2010), and *Ocean Literacy Scope*

and Sequence for Grades K–12 (National Marine Educators Association, 2010), and even develop new science standards for the 21st century. However, if everyone continues to trivialize the Earth Sciences, then two things will happen: the U.S. will never reach its goal of scientific literacy as stated in the *National Science Education Standards* (NRC, 1996) for all citizens, and we will continue to have unqualified teachers with fewer students taking the Earth Sciences. This will result in fewer students majoring in the geosciences as a career path, and the cycle of disrespect will persist and nothing will change. IT IS TIME TO STAND UP FOR EARTH SCIENCE!

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