Earth and Space Sciences Education in U.S. Secondary Schools: Key Indicators and Trends

Earth and Space Science Report, Number 2.1
July 2015

Center for Geoscience & Society
american geosciences institute

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Center For Geoscience and Society

AGI was founded in 1948, under a directive of the National Academy of Sciences, as a network of associations representing geoscientists with a diverse array of skills and knowledge of our planet. The Institute provides information services to geoscientists, serves as a voice of shared interests in our profession, plays a major role in strengthening geoscience education, and strives to increase public awareness of the vital role the geosciences play in society's use of resources, resilience to natural hazards, and the health of the environment.

The mission of AGI's Center for Geoscience and Society is to enhance geoscience awareness across all sectors of society. The Center accomplishes this by generating new approaches to building geoscience knowledge, engaging the widest possible range of stakeholders, and creatively promoting existing and new resources and programs.

If you have questions concerning this report, please contact:

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Earth and Space Sciences Education in U.S. Secondary Schools: Key Indicators and Trends

The Center for Geoscience and Society, a service of the American Geosciences Institute, is pleased to release its second annual report on the status of secondary Earth and Space Science education in the United States. This report includes information on the presence of the Earth and Space Sciences in:

- science education standards;
- high school graduation requirements;
- high stakes state-level science assessments;
- college admission requirements; and
- the Advanced Placement program.

The Center report will provide a yearly "snapshot" of the health of the Earth and Space Sciences in our nation's school systems. This report is based on data collected by the American Geosciences Institute from State Education Agency (SEA) websites and from interviews with SEA officials for all 50 states and the District of Columbia between March and June 2015. This report is available for download from AGI's website: www.americangeosciences.org.

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Introduction

Why Are the Earth and Space Sciences Important?

Earth and Space Science topics appear in the news every day and affect all our lives. We deal with the effects of natural hazards, make decisions about resource use, and adjust our activities according to the daily weather forecast. Secondary school students may learn about Earth and Space Science topics in courses addressing environmental science, integrated science, physical geography, or in other science subjects. However, the Earth and Space Sciences are not necessarily a required part of the curriculum in many U.S. schools, particularly at the high school level. American youth who do have the opportunity to study the Earth and Space Sciences in school can learn about:

- How Earth works as a set of interconnected systems;
- Effects that human decisions can have on the various parts of the Earth system;
- Why natural hazards occur and what actions to take when they do;
- Earth's place in the Solar System and beyond;
- Where natural resources come from, how they are used, and how they can be conserved; and
- How Earth changes over time and what the evidence is for those changes

The release of the *Next Generation Science Standards* (Achieve, 2013) puts the Earth and Space Sciences on an equal footing with the Life Sciences; the Physical Sciences; Engineering and Technology and Applications of Science. Yet, the reality of practice falls short of these standards:

- Only two states require a year-long Earth/Environmental Science course for high school graduation, whereas thirty (30) states require a Life Science course and twenty (20) states require a Physical Science course.
- A high school Earth and Space Science course is not universally accepted by four-year institutions of higher education for admission.
- There is no Advanced Placement (AP) Earth and Space Science course or examination, which has several implications, including the fact that AP courses can be a major driver for a subject's inclusion in the high school curriculum nationwide.

Background

The status of secondary Earth and Space Science education has been under review for years. In the early 2000s, the National Science Foundation supported two conferences for members of the education community to assess the status of Earth and Space Science education in the United States. These conferences, entitled Revolution in Earth and Space Science Education (2001) and The Second Revolution in Earth and Space Science Education (2004), had the goal of promoting Earth and Space Science instruction in U.S. schools. Recommendations from the first conference report included forming state-based alliances and developing an "Annual Snapshot" of the status of Earth and Space Science education in the United States. The second meeting brought together representatives from four states (New York, California, North Carolina and Texas), as well as members of geoscience organizations, to explore how such alliances could work to promote Earth and Space Science education.

As a follow-up to the recommendations arising from both "Revolution" meetings, the American Geological Institute (AGI – now the American Geosciences Institute) produced reports on the Status of Earth and Space Science Education in 2002 and 2004 (Smith et al). AGI also created the Pulse of Earth Science web site in 2007 featuring state-by-state information on standards, assessments, teacher certification requirements, and other pertinent data. In addition, with support from the National Science Foundation and private entities, AGI hosted a K-12 Earth and Space Science education summit in early 2010 in Houston, Texas. The purpose of the summit was to bring together leaders in U.S. Earth and Space Science education to discuss the current status of the Earth and Space Sciences in K-12 schools, define problems, and suggest methods for addressing those problems.

Attendees at the summit, which included representatives from federal and state agencies, universities, science societies, school districts, and industry, formed working groups to explore what was happening across the country with regard to:

- Perception of Earth and Space Science courses by school systems (graduation requirements, high stakes assessments, and standards);
- Status of college acceptance of high school Earth and Space Science courses;
- Challenges to teaching Earth and Space Science topics such as evolution and climate change in schools;

- Possibility of an AP Earth and Space Science course and examination; and
- Preparation of Earth and Space Science teachers.

After the summit, AGI and partners planned and implemented several studies to gauge the status of the Earth and Space Sciences in the U.S. educational system. This report, which will be updated and released annually, is the result of a subset of those studies. Reports on other topics addressed by summit attendees will be released at a later date. A report on the status of the Earth and Space Sciences at the elementary school level was released in July 2015.

Acceptance of Earth and Space Science Courses for Admission to Four-Year Institutions of Higher Learning

One of the points that arose from the 2010 summit was the perception that school districts were not offering high school Earth and Space Science courses because of the belief that colleges will not accept these for admission, as Earth and Space Science is not universally considered to be a laboratory course.

To test out this assertion, in 2015, AGI examined the acceptance policies of 175 four-year institutions of higher learning, to determine whether or not they accepted a high school Earth and Space Science course for admission. At least four colleges and universities were contacted in each state and the District of Columbia. These represented both public and private institutions of various sizes.

In many cases, current admission requirements were clearly posted on the institutions' web sites. When this was not the case, AGI staff contacted admissions offices directly for information. The results were as follows:

- 77.7 percent of institutions did accept an Earth and Space Science course for admission.
- 13.7 percent did not have specific science course requirements for admission.
- 8.6 percent did not accept an Earth and Space Science course for admission, as these institutions stated that they did not consider it to be a laboratory course.

These findings clearly contradict the common assumption that, overall, colleges and universities find a high school Earth and Space Science course unacceptable for admission. There is still, however, a perception among a minority of institutions that an Earth and Space Science course is not a laboratory course.

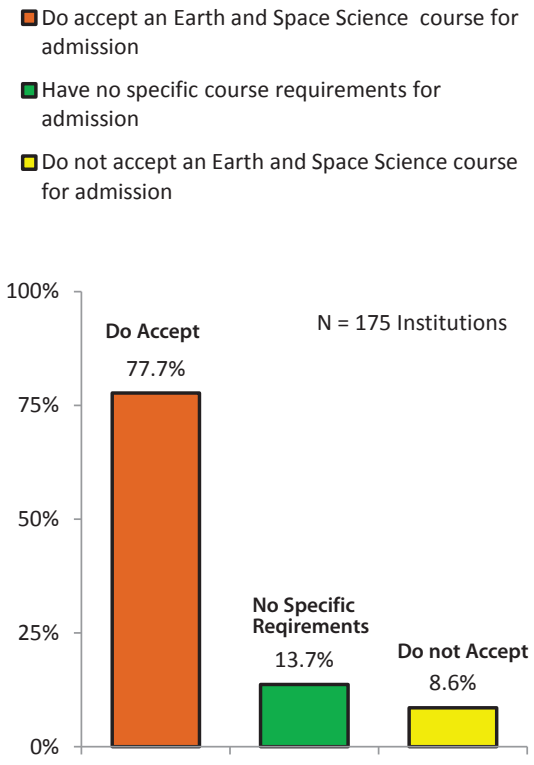

Figure 1. Four-Year Institutions of Higher Learning Accepting Earth and Space Science Courses for Admission

Graduation Requirements and the Earth and Space Sciences

With only two (2)* exceptions, states require between two and four credits of science to graduate from high school.

- Seven (7) states require two (2) credits;
- Thirty-seven (37) states require three (3) credits; and
- Four (4) states and the District of Columbia require four (4) credits.

The 1996 *National Science Education Standards* and the 2013 *Next Generation Science Standards* consider the Earth and Space Sciences on a par with the Life Sciences and the Physical Sciences. To assess whether or not this equality was borne out in practice, AGI collected data on high school science graduation requirements for all 50 states and the District of Columbia during academic year 2014-2015. These requirements typically appeared on State Education Agency web sites. AGI also contacted State Education Agency personnel and school district level personnel for additional information about science graduation requirements. The results appear below and in Figure 2.

- Two states required a year-long Earth/Environmental Science course for graduation, whereas thirty (30) states required year-long Life Science courses and twenty (20) states required year-long Physical Science courses for graduation. (The definition of a Physical Science course varied from state to state, but typically encompassed physical science, chemistry and/or physics.)
- Five (5) states required the study of Earth and Space Science concepts (although not a full-year course) as a requirement for graduation.
- Twenty-two (22) states accepted an Earth and Space Science course for graduation. Of these, eleven (11) specifically stated that the science requirement must be "laboratory-based."
- Twenty-one (21) states and the District of Columbia had science course requirements, but did not mandate the content of those courses. Of these, seven (7) specifically stated that the science requirement must be "laboratory-based."

These data illustrate that, while national science standards and guidelines consider the Earth and Space Sciences as equal in rigor and importance to the Life Sciences and the Physical Sciences, this equality is not reflected in states' actual high school science graduation requirements.

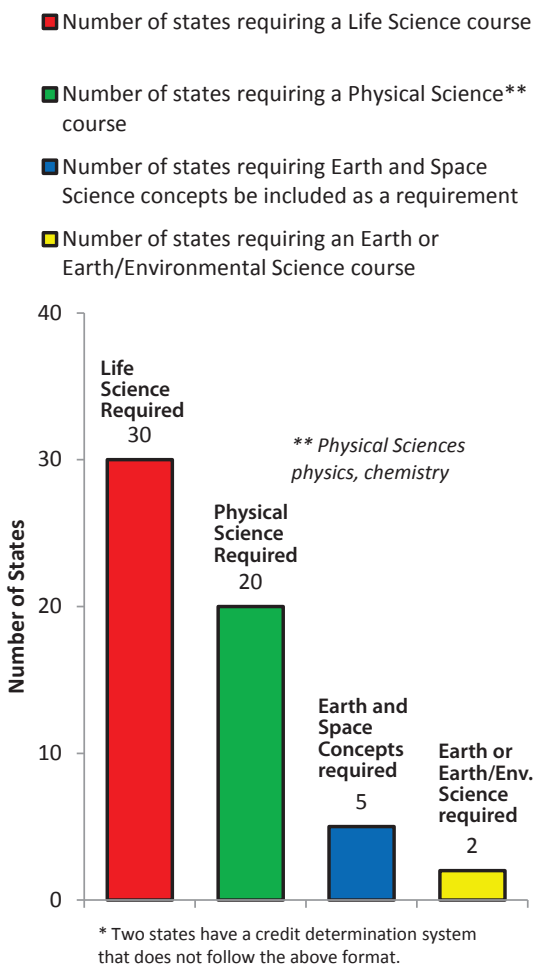

Figure 2. States Requiring Specific Science Courses and/or Content for High School Graduation

Status of the Earth and Space Sciences in State Standards

The *Next Generation Science Standards* were developed with the cooperation of twenty-six (26) states. However, at present, no states are required to adopt these standards, as each state decides upon its own science education standards. In some states, this decision is made at the district or even school level. As of April 12, 2015, the District of Columbia and thirteen states have officially decided to adopt the *Next Generation Science Standards*: California, Delaware, Illinois, Kansas, Kentucky, Maryland, Nevada, New Jersey, Oregon, Rhode Island, Vermont, Washington, and West Virginia. It will be interesting to observe, over the coming years, how these states approach the task of addressing these new standards, and what effect the standards have on graduation requirements, high stakes assessments, choice of curricula and teacher professional development.

To assess whether and where Earth and Space Science concepts are included at the secondary level in the United States currently, AGI reviewed the secondary science standards for all 50 states and the District of Columbia. This review was conducted during Academic Years 2011-2012, 2012-2013, and again in 2014-2015. The review was solely to identify if Earth and Space Science topics were included in each state's standards and to what extent – not to evaluate the quality of those standards. The Earth and Space Science topics in states' standards included Earth system interactions, plate tectonics, weather, climate, Earth's changes over time, astronomy, oceanography, Earth structure, surface processes, Earth resources, natural hazards and others.

The results of this analysis revealed that Earth and Space Science concepts are included, to a fairly equivalent extent, in state secondary science standards in fifty (50) states and in the District of Columbia. All states and the District of Columbia also include Life Science and Physical Science standards at the secondary level.

Status of the Earth and Space Sciences in High Stakes Assessments

Because state standards included Earth and Space Science concepts in approximately the same quantity as the Life and Physical Sciences, AGI set out to determine whether state secondary science assessments evaluated students' mastery of Earth and Space Science concepts to the same extent as their understanding of Life and Physical Science concepts.

While states and districts use many types of science assessments, AGI focused on collecting information about high-stakes testing at the secondary level. These high-stakes tests were either comprehensive assessments or end-of-course assessments. The comprehensive assessments were usually administered to all students at particular grade levels and covered a variety of topics. End-of-course assessments were typically taken after a particular course was completed and focused on the subject matter of that course (Mielke, 2011).

Throughout Academic Year 2014-2015, AGI collected data on the content of high-stakes science assessments for all 50 states and the District of Columbia from State Education Agency web sites and by contacting state science supervisors and other district personnel. The findings appear below and in Figures 3-5 (see page 7).

Earth and Space Science Concepts Assessed

Fifty (50) states assessed Earth and Space Science concepts at the secondary level. Of these, sixteen (16) states assessed Earth and Space Science concepts only at the middle school level; no states (0) assessed Earth and Space Science concepts only at the high school level, and thirty-four (34) states assessed Earth and Space Science concepts at both the middle and high school levels.

Life Science Concepts Assessed

Fifty (50) states and the District of Columbia assessed Life Science concepts at the secondary level. Of these, no states (0) assessed Life Science only at the middle school level; no states (0) assessed Life Science only at the high school level, and 50 states and the District of Columbia assessed Life Science at both the middle and high school levels.

Physical Science Concepts Assessed

Fifty (50) states and the District of Columbia assessed Physical Science concepts at the secondary level. Of these, fourteen (14) states assessed Physical Science concepts only at the middle school level; no states (0) assessed Physical Science only at the high school level; and thirty-seven (37) states assessed Physical Science at both the middle and high school levels.

Earth and Space Science and Advanced Placement Examinations and Courses

Advanced Placement (AP) courses are frequently perceived as indicators of which high school science subjects are acceptable to colleges. This is important, since a student's intent in taking AP courses is often to gain college credit by scoring highly enough on the relevant AP examination.

At this time, there are AP examinations and courses for Biology, Chemistry, Physics and Environmental Science (College Board, 2015). However, there is no Advanced Placement examination or course for the Earth and Space Sciences. In contrast, AP Environmental Science is offered to some extent in all 50 states and the District of Columbia (College Board, 2014). Students actually taking the AP examination for Environmental Science can range from the tens to the thousands/state (College Board, 2014), but this only represents a subset of all students taking the AP course in this topic area. What is more important to note is that a review of the most recent AP Environmental Science course topics revealed that a significant number of those topics cover Earth Science concepts. The presence of this Earth Science content, however, is not reflected in the title of the course or the examination.

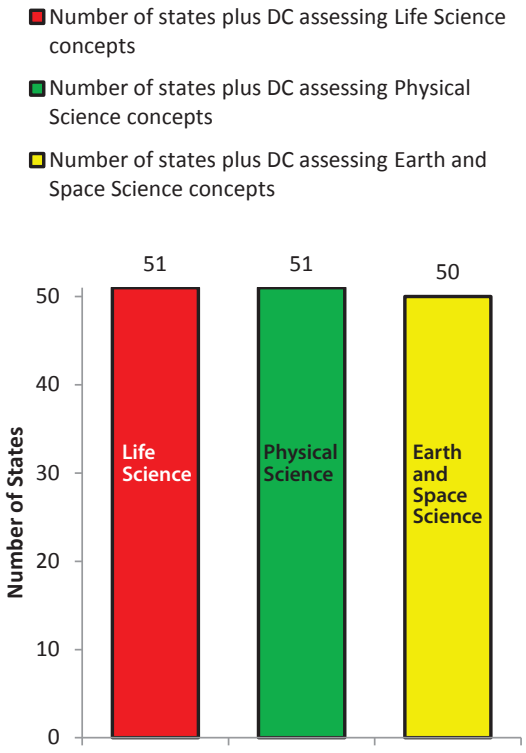

Figure 3. States Assessing Life Science, Physical Science and Earth and Space Science Concepts on Secondary Science Assessments

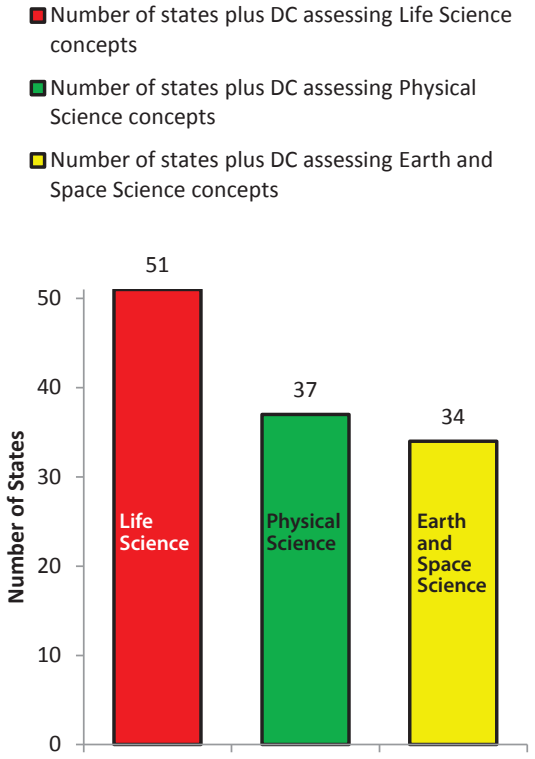

Figure 4. States Assessing Life, Physical and Earth and Space Science Concepts in Both Middle and High School

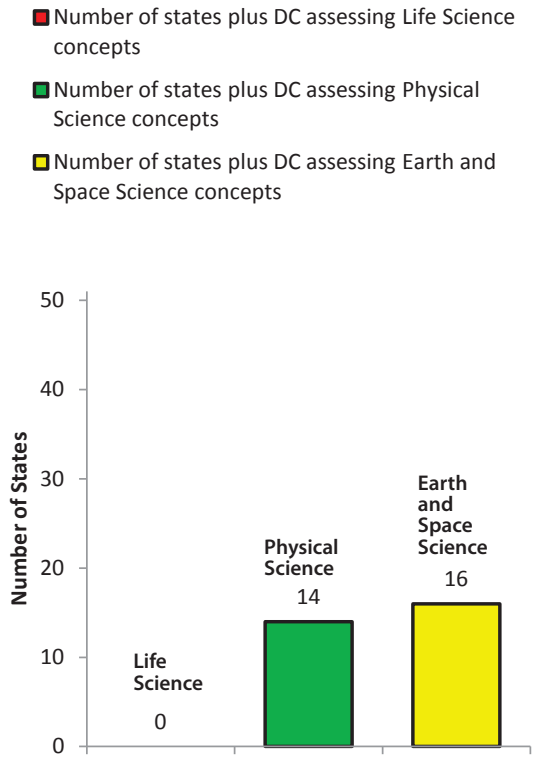

Figure 5. States Assessing Life, Physical and Earth and Space Science Concepts in Middle School Only

DISCUSSION

This report, while only a snapshot of a landscape that is continually shifting over time, provides a perspective on the current state of the Earth and Space Sciences in U.S. secondary education. Although the Earth and Space Sciences are accorded equal status with the Life and Physical Sciences in national standards and guidelines, this emphasis is not manifested in practice, as indicated by state graduation requirements and secondary science assessments. The absence of an AP Earth and Space Science course and examination further attests to the subject's subordinate status as compared to other sciences.

However, Earth and Space Science courses have a higher rate of acceptance for admission to four-year colleges (77.7 percent), than was originally assumed. In addition, state standards include Earth and Space Science concepts at a level essentially equal to that of Life and Physical Science concepts. For total equality, states, particularly those that adopt the Next Generation Science Standards, will need to find ways to raise the status of the Earth and Space Sciences in their secondary programs. This could be accomplished through changes in the subject's relevance to graduation requirements, presence on assessments, the designation of Earth and Space Science courses as laboratory courses, through the establishment of an AP Earth and Space Science program, or through other methods yet to be developed.

It is worth noting that students who do not receive a commensurate education in the Earth and Space Sciences are less prepared for the challenges and opportunities that await them in adult life, whether in competing in the global job market or making informed personal and voting decisions on such vital issues as resource use, climate change, natural hazards, space exploration and Earth stewardship. As stated in the preface to the Earth Science Literacy Principles (Wysession et al, 2012):

> *Earth Science Literacy is especially important at this time in history. There are many challenges facing humanity—dwindling energy and mineral resources, changing climates, water shortages—directly relating to the Earth sciences. There are many difficult decisions that governments, local and national, will have to make concerning these issues, and how well humans survive the twenty-first century will depend upon the success of these decisions. We need governments that are Earth science literate.*
>
> *Human history is a record of the creativity and ingenuity of people solving difficult problems. The solutions to the current Earth-science-related challenges will also come from human creativity, as individuals or corporate businesses. However, as our modern society and its needs have become increasingly complex, so have the solutions. It will take a deep and subtle understanding of Earth's systems for future generations to be able to feed, clothe, house, and provide a meaningful existence for all humans. We need citizens and businesses that are Earth science literate.*

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Delaware: http://www.doe.k12.de.us/
District of Columbia: http://www.dcps.dc.gov
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Georgia: http://www.gadoe.org/
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