

Education in the Earth and Space Sciences in U.S. Secondary Schools

Key Indicators and Trends

Center for Geoscience Education and Public Understanding
A Service of the American Geosciences Institute





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1.0 Introduction

The Center for Geoscience Education and Public Understanding, a service of the American Geosciences Institute, is pleased to release its first annual report on the status of secondary Earth and Space Science education in the United States. The report includes statistics on the presence of the Earth and Space Sciences in:

- national and state science education standards;
- high school graduation requirements;
- high stakes 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.

2.0 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 will learn about:

- How Earth works as a set of interconnected systems;
- Effects 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 in national science education standards 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 one (1) state **requires** a year-long Earth/Environmental Science course for high school graduation, while thirty-two (32) states require a Life Science course and twenty-seven (27) 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, although AP courses are a major driver for a subject's inclusion in the high school curriculum nationwide.

3.0 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 convene and 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 annual 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 an 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 schools, define problems, and suggest methods for solving those problems.

Attendees at the summit, which included representatives from federal 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 such Earth and Space Science topics 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 those studies. Reports on other topics addressed by summit attendees will be released at a later date, including a report on the status of the Earth and Space Sciences at the elementary level.

4.0 Indicators

4.1 College Acceptance of Earth and Space Science Courses

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

To test out this assertion, AGI examined the acceptance policies of 240 four-year institutions of higher learning, beginning in mid-2010 and continuing to the present, to determine whether or not they accepted a high school Earth and Space Science course as acceptable 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 (Fig.1):

- 77.7 percent of institutions **did** accept an Earth and Space Science course for admission.
- 17.0 percent did not have specific science course requirements for admission.
- 5.3 percent **did not** accept an Earth and Space Science course for admission, as these institutions did not consider it a laboratory course.

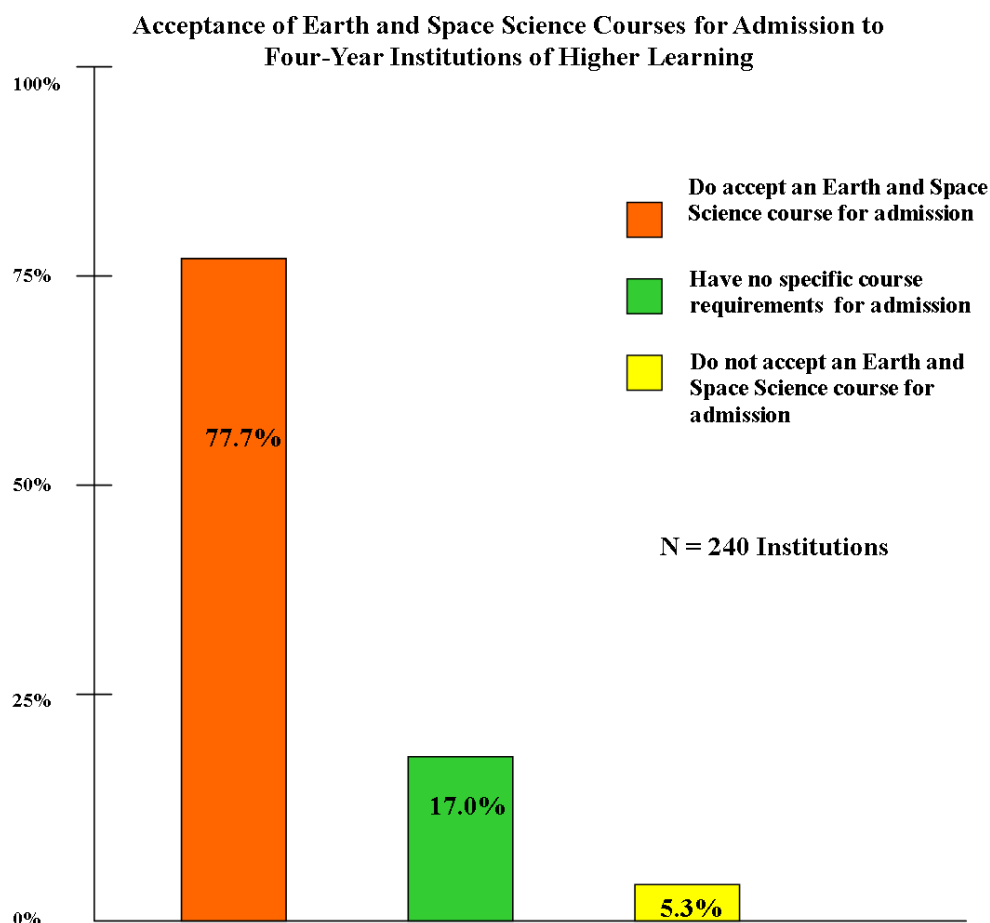


Figure 1

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. This study is ongoing.

4.2. 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.

- Nine (9) states require two (2) credits;
- One (1) state requires between two (2) and three (3) credits;
- Thirty-four (34) states require three (3) credits; and

- Five (5) states require four (4) credits.

**Two states have a credit determination system that does not follow the above format.*

Since both 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, one might expect that, by now, this equality would be reflected in states' high school graduation requirements. AGI tested this premise by collecting data on high school science graduation requirements for all 50 states and the District of Columbia during Academic Year 2012-2013. These requirements typically appeared on the web sites of each state's board of education. AGI also contacted personnel at state boards of education for verification of the graduation requirements. The results appear below and in Figure 2.

- One state required a year-long Earth/Environmental Science course for graduation, whereas thirty-two (32) states required year-long Life Science courses and twenty-seven (27) 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.)
- In addition to the state requiring an Earth and Space Science course for graduation, six (6) states required the study of Earth and Space Science *concepts* as a requirement for graduation.
- Thirty-six (36) states and the District of Columbia *accepted* an Earth and Space Science course for graduation. Of these thirty-seven (37) entities, sixteen (16) specifically stated that the science requirement must be "laboratory-based."

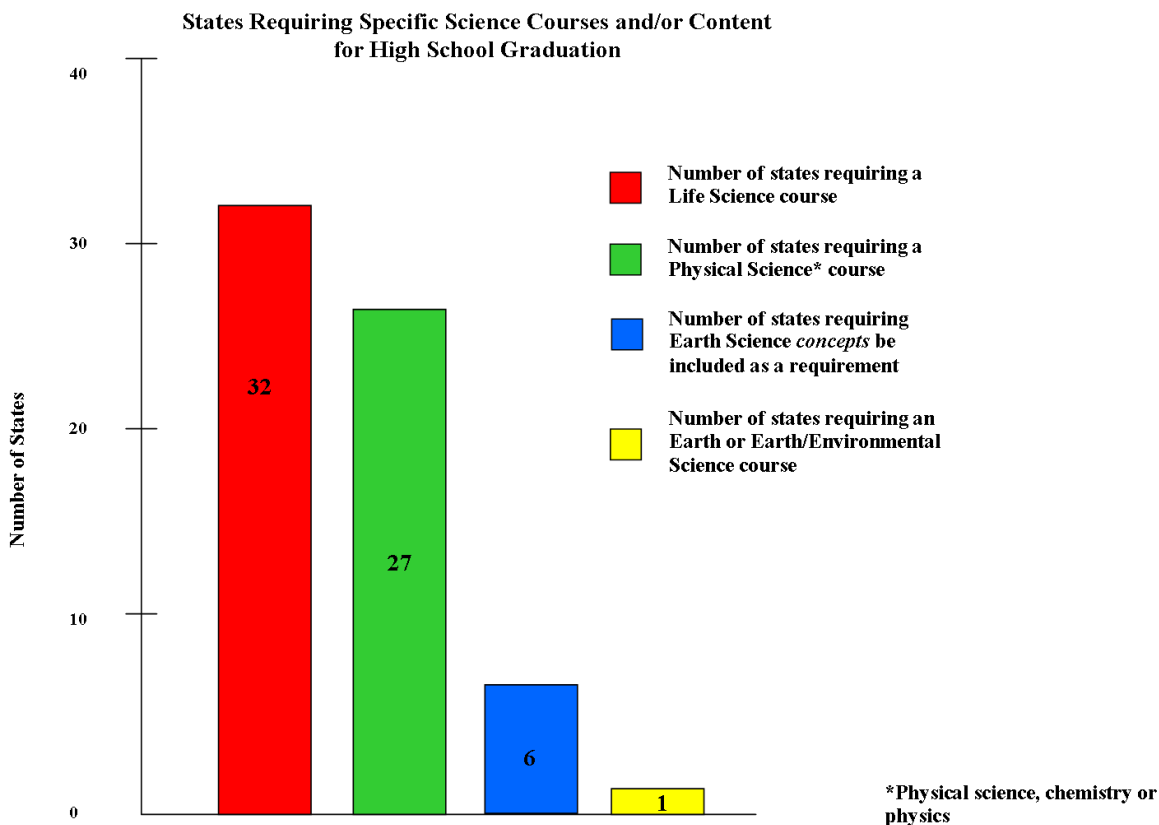


Figure 2

These data illustrate that, while national science standards 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.

4.3. Status of the Earth and Space Sciences in State Standards

The *Next Generation Science Standards*, released in April 2013, were developed with the cooperation of twenty-six (26) states. However, at present, no states are required to adopt any set of national subject area standards. Each state decides upon its own science education standards, and in some states this decision is made at the district or even school level.

To assess whether and where Earth and Space Science concepts are included at the secondary level in the United States, AGI reviewed the current science standards for all 50 states and the District of Columbia. This review was conducted during Academic Years 2011-2012 and 2012-2013. The review was solely to identify if Earth and Space Science topics were included in each state's standards – not to evaluate the quality of those standards. The Earth and Space Science topics in states' standards included Earth system interactions, 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 are as follows:

- Earth and Space Science concepts are included, to some 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.

4.4 Status of the Earth and Space Sciences in State High Stakes Assessments

Because national standards gave the Earth and Space Sciences emphasis equal to that of the Life and Physical Sciences, and because state standards similarly stipulated Earth and Space Science concepts with approximately the same frequency as these other sciences, AGI set out to determine whether state secondary science assessments evaluated students' mastery of Earth and Space Science concepts as rigorously as their learning of Life and Physical Science concepts.

While states 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 2012-2013, AGI collected data on the content of high-stakes state science assessments for all 50 states and the District of Columbia from state board of education web sites and through a survey of state science supervisors and other district personnel. The findings appear below and in Figures 3-6.

Earth and Space Science Concepts Assessed

Forty-seven (47) states and the District of Columbia 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; three (3) states assessed Earth and Space Science concepts only at the high school level, and twenty-nine (29) states assessed Earth and Space Science concepts at both the middle and high school levels.

Life Science Concepts Assessed

Forty-nine (49) states and the District of Columbia assessed Life Science concepts at the secondary level. Of these, one (1) state assessed Life Science only at the middle school level; three (3) states and the District of Columbia assessed Life Science only at the high school level, and forty-five (45) states assessed Life Science at both the middle and high school levels.

Physical Science Concepts Assessed

Forty-seven (47) states and the District of Columbia assessed Physical Science concepts at the secondary level. Of these, sixteen (16) 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-two (32) states assessed Physical science at both the middle and high school levels.

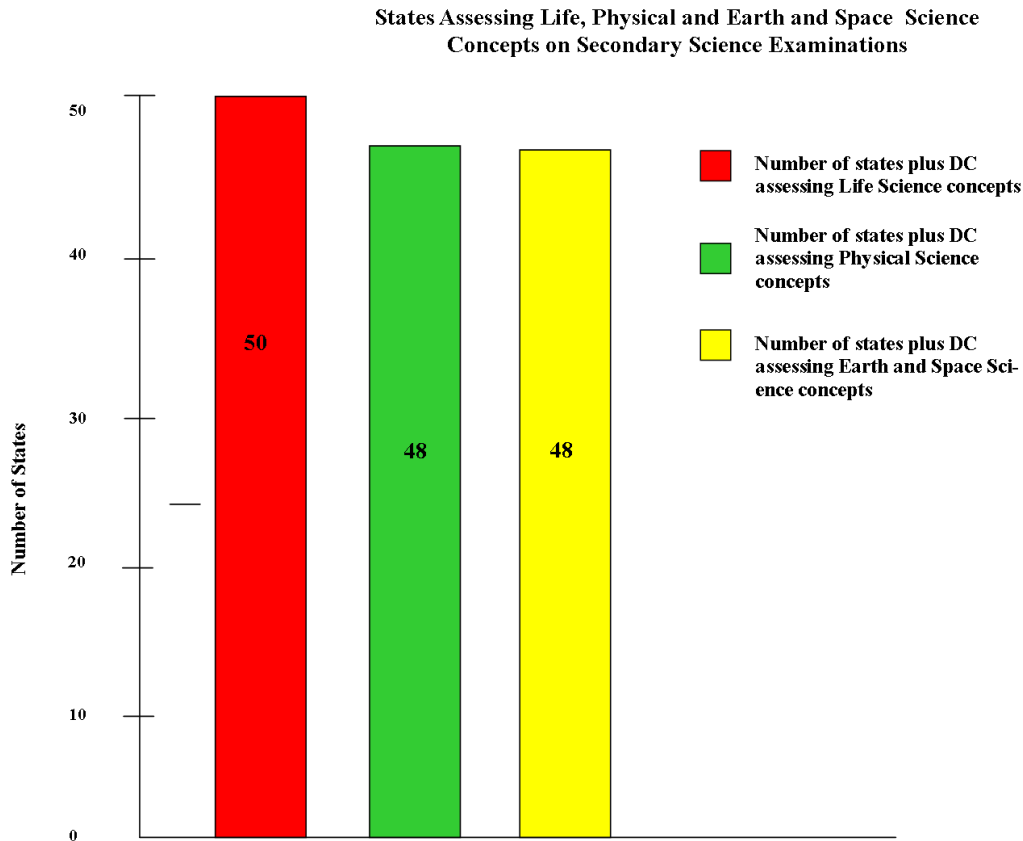


Figure 3

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

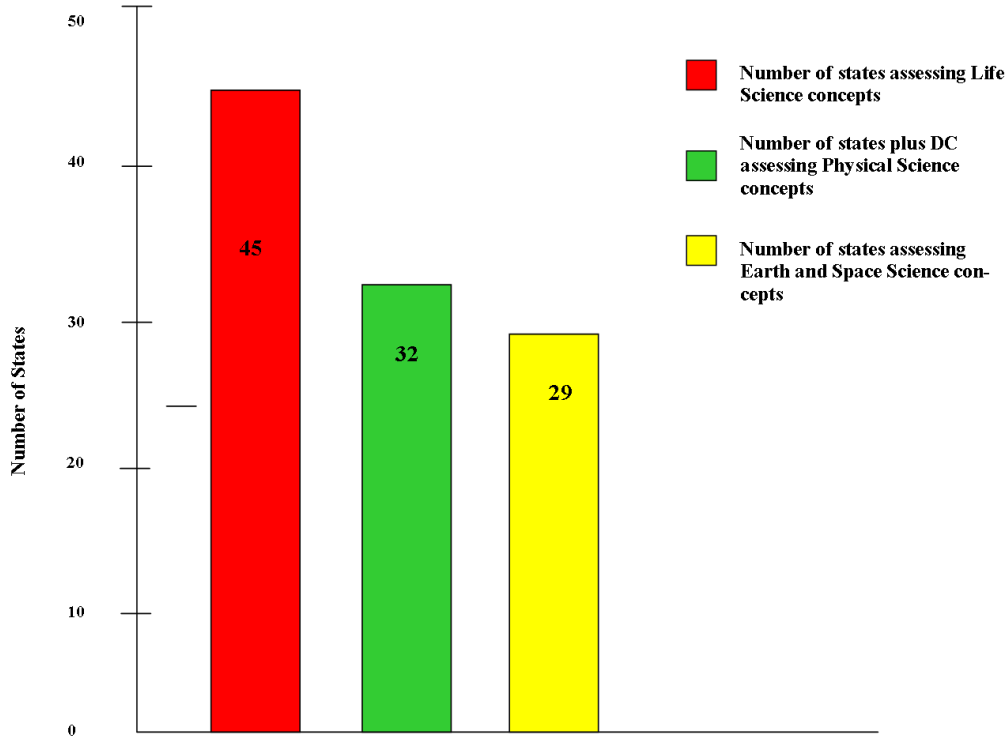


Figure 4

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

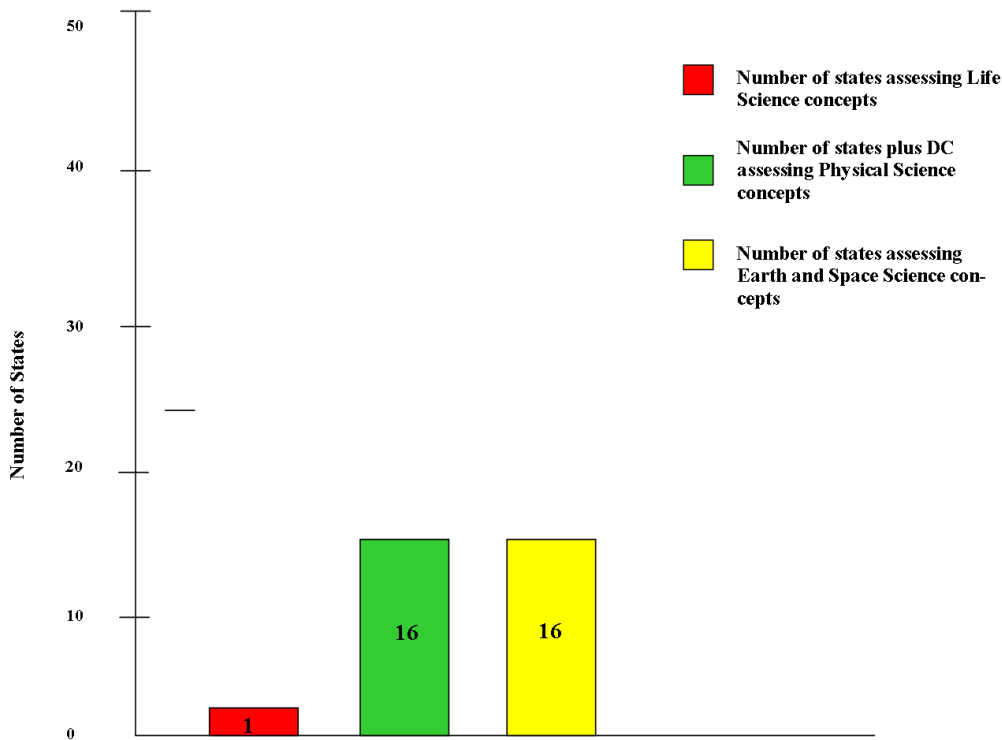


Figure 5

States Assessing Life and Earth and Space Science Concepts in High School Only

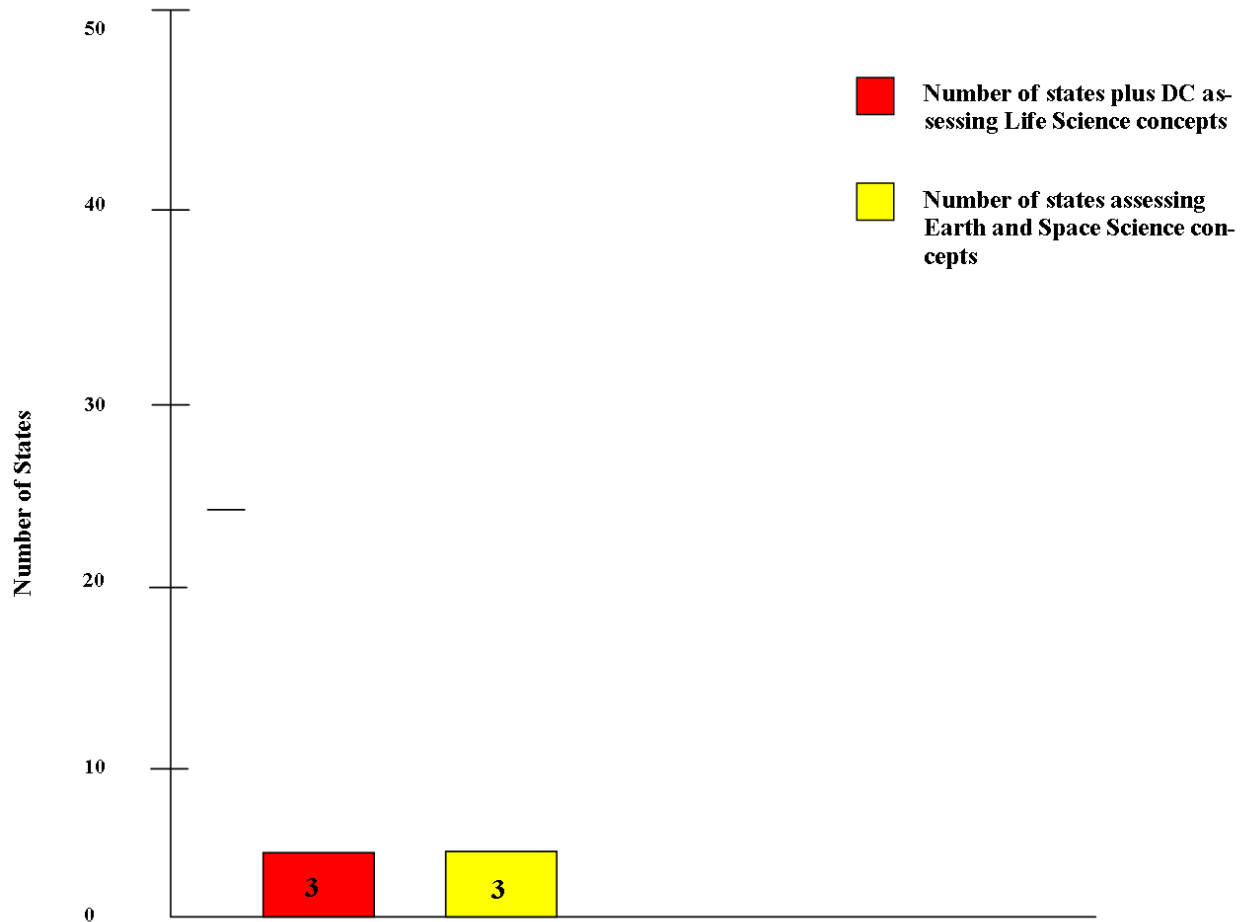


Figure 6

4.5 Earth and Space Science and AP Examinations and Courses

AP courses are frequently perceived as indicators of “college acceptable” science subjects, as a student’s intent in taking these courses often is to gain college credit by scoring highly enough on the relevant AP examination.

At this time, there are Advanced Placement examinations and courses for Biology, Chemistry, Physics and Environmental Science (College Board, 2013). 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, 2012). Students actually taking the AP examination for Environmental Science can range from the tens to the thousands/state (College Board, 2012), 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 standards revealed that approximately 50 percent of those standards covered Earth Science topics. The significant presence of this Earth Science content, however, is not reflected in the name of the course or examination.

5.0 Discussion

This report, while only a snapshot of a landscape that is continually shifting over time, provides a valuable 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 by national and state science education standards, 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 unequal 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 nearly equal to that of Life and Physical Sciences 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, and/or through the establishment of an AP Earth and Space Science program.

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.

6.0 Partial References (final e-copy will have complete list of state board of education web sites accessed for data)

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