

Report on the Status of K-5 Geosciences Education in the United States

A 50-State Analysis of K-5 Geosciences Education, Number 1.1, July 2015



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Report on the Status of K-5 Geosciences Education in the United States

The "Report on the Status of K-5 Geosciences Education in the United States" presents a snapshot of geosciences education in the nation's elementary schools by highlighting K-5 geosciences education indicators pertaining to teacher preparation, curriculum, instruction, learning contexts, extra-curricular programs, monitoring systems, and accountability. 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 September 2014 and June 2015. This report is available for download from AGI's website: www.americangeosciences.org.

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Introduction

The intent of this report is to inform discussion and encourage action that enhances opportunities for children’s learning about the geosciences. The geosciences have an increasingly prominent role in social life. Daily news stories about energy resources, environmental change, hazardous events, and many other topics remind us of the importance of understanding the dynamic Earth systems on which we all depend. Knowledge from diverse fields such as geology, oceanography, climatology, astronomy, and many others provide the information and conceptual models that guide decision-making at personal and societal levels. Individuals who are informed about the geosciences are able to take part in public discourse about current issues and more informed personal decisions. Developing geosciences knowledge early in life provides a foundation for informed and thoughtful personal choices and civic engagement. As well, since experiences influence interests that develop later in life, early development of geosciences knowledge opens avenues for both personal and professional opportunities.

This report focuses on the development of geosciences knowledge in formal settings during childhood—that is, in Kindergarten through Grade 5 (K-5) classrooms. These settings provide important geosciences learning experiences. Yet, geosciences knowledge can also be gained through informal learning opportunities, such as museums and nature centers, and through personal interests and hobbies such as camping, star gazing, and others. Sometimes formal and informal opportunities overlap, as well (e.g., a school field trip to a museum could be seen as a combination of formal and informal learning). Therefore, the report at times uses data about informal, extra-curricular, and co-curricular opportunities for geosciences learning to contextualize data about K-5 classroom learning.

The report’s focus on K-5 classroom learning is also strategic. Informal learning opportunities are often related to discrete family and community factors that cannot be characterized well in the general terms required in a report such as this. As well, in that the intent of the report is to encourage action, having a focus for that action allows for greater clarity regarding what data are relevant. In this case, that focus is formal teaching of geosciences concepts, methods of inquiry, and even career awareness.

What occurs in K-5 classrooms is, of course, affected by many factors, which led to the collection of data at many levels for this report. The lessons teachers use to engage students are affected by standards, accountability measures, material support, scheduling, and many other elements. This report provides information regarding a large set of those factors.

That K-5 instruction is affected by many factors also demonstrates that a report such as this has many audiences. Teachers, school administrators, parents, politicians, and others all have a stake in the quality of geosciences instruction, and all have a role to play in enhancing that instruction. Therefore the report has been developed to include information that is important to varied stakeholders.

Ultimately, the intent is for this report to be a starting place for the important discussions that need to take place to bring about coherent and positive change in geosciences education, and ultimately in society’s responses to some of the most pressing issues of our time.

Report Structure

Geosciences education can be characterized by a host of indicators, including state policies, district structures, school supports, community involvement, parent expectations, and the availability of instructional resources, among others. The indicators presented in this report were selected and designed to provide a valid, state-by-state and national description on the condition of geosciences education in elementary schools. The key indicators are organized into seven major topical areas:

- Teacher preparation
- Curriculum
- Instruction
- Learning contexts
- Extra-curricular programs
- Monitoring systems
- Accountability

This study is designed to answer seven central questions for each state. Each of those questions is related to a major topical area:

1. What evidence can be provided that the state's teachers are prepared and supported with respect to teaching geosciences topics?
2. What evidence is there that there has been conscientious thought given to what is to be taught to students with respect to the geosciences?
3. What evidence is there that the approaches to instruction that are promoted for use with respect to geosciences topics are given conscientious consideration?
4. What evidence is there that the contexts in which children learn geosciences topics are well suited to help students learn geosciences topics?

5. To what extent do children have access to extra-curricular and co-curricular opportunities to learn geosciences?
6. To what extent is student learning in the geosciences monitored?
7. In what specific ways do student outcomes related to geosciences education matter?

Each of the seven central questions is answered according to several narrower sub-questions. The findings are reported for each sub-question. The findings are descriptive and meant to present an overview of particular conditions related to geosciences education indicators at the elementary level. The findings do not infer a cause for reported trends or measure the effectiveness of educational approaches or policies.

Findings: Teacher Preparation

1. What evidence can be provided that the state's teachers are prepared and supported with respect to teaching geosciences topics?
 - a. Does state licensure require courses in geosciences areas?

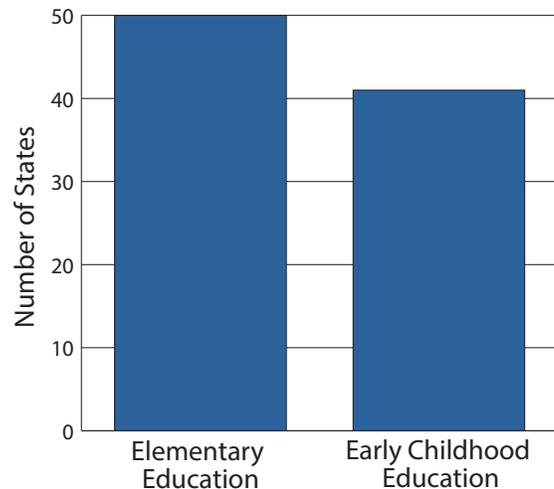
Within the United States, each state regulates the licensing and credentialing of its own teachers. While many general requirements are similar, there are specific requirements for teacher certification and renewal that vary from state to state.

At the elementary level, all states and the District of Columbia require a minimum of a bachelor's degree from an accredited college/university to become a certified teacher. In addition, all states and the District of Columbia require potential teachers to complete a state-approved teacher preparation program from an accredited college/university or undergo a teacher preparation alternative certification program. Most states do not advertise the specific requirements for teacher preparation programs, but typically they consist of a combination of coursework and fieldwork. The coursework often includes instruction on foundational knowledge and skills, pedagogy, and preparing teacher candidates to implement learning experiences in their field of study. The fieldwork component can include observations in classrooms and supervised student teaching/internship experiences of varying lengths and configurations.

Teacher endorsement areas at the elementary level vary from state to state.¹ The most common credential issued is an Elementary Education license. Offered by 49 states and the District of Columbia, this allows a teacher to teach grade spans Kindergarten or Grade 1 through Grade 5 or Grade 6. Many states offer an additional credential that targets the early elementary school years. Offered by 40 states and the District of Columbia, an Early Elementary Education or Early Childhood Education license typically covers Preschool or Kindergarten to Grade 2 or Grade 3. Only Pennsylvania offers a credential that does not match these grade spans, licensing teachers at the Preschool to Grade 4 levels and Grade 4 to Grade 8 levels.

¹ To simplify the discussion, in many instances the District of Columbia is included when the term 'state' is used in a general way.

Figure 1: **Elementary Level Teacher Endorsement Areas**



49 states and the District of Columbia require teaching candidates to pass either state-specific teacher tests and/or commercial exams (e.g., the PRAXIS series) for their endorsement area.² Only Montana does not have testing requirements for licensure. The subject areas tested and the content of the exams vary from state to state.

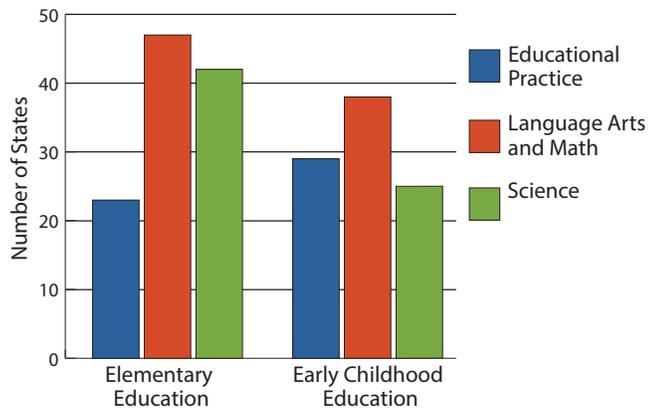
For the Elementary Education credential, 22 states and the District of Columbia require candidates to pass a separate educational practice examination. Topics assessed in this exam might include human development, learning processes, instructional processes, and educational psychology. 46 states and the District of Columbia require knowledge tests in reading and writing or language arts and mathematics. 41 states and the District of Columbia require candidates applying for an Elementary Education credential to take an additional science test that measures their knowledge of Earth Science, Life Science, and Physical Science concepts. Only 8 states do not require a science test for Elementary Education candidates.

Similarly, for the District of Columbia and the 40 states that offer an Early Elementary Education credential, 29 require a separate educational practice examination. 37 states and the District of Columbia require

² The Praxis Series tests are used by many states to measure teacher candidates' knowledge and skills as part of the teacher licensure and certification process. Praxis series tests are developed, administered, and scored by Educational Testing Service, a nonprofit organization that "conducts assessment and policy research and develops assessments and related services to advance quality and equity in learning worldwide." Details at: <http://www.ets.org/praxis/>

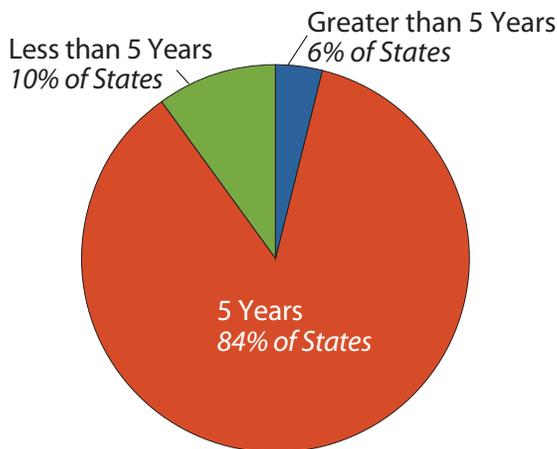
knowledge tests in reading and writing or language arts and mathematics while 24 states and the District of Columbia require an additional knowledge test in science that assesses Earth Science, Life Science, and Physical Science concepts.

Figure 2: State Licensure and Subject Area Examinations



For 44 states, the Elementary Education or Early Childhood license is valid for 5 years. Arizona validates licenses for 6 years. For 5 states, the period of validity is less than 5 years (District of Columbia, Missouri, New Hampshire, New Mexico, and Vermont). New Jersey offers a permanent license that does not require renewal.

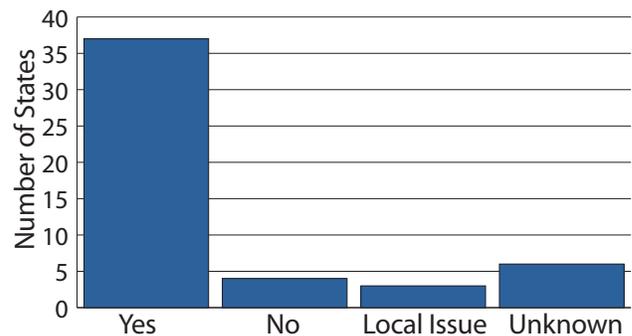
Figure 3: License Validity Periods



Except for New Jersey, all states and the District of Columbia require teachers to renew their licenses by completing a specific number of planned and approved professional growth activities, which may include university courses and in many cases include approved professional development offered by the school system in which the teacher works. Typically, the description of

the required content for professional growth activities is made available at the local level. In interviews, SEA officials from each state were asked whether elementary teachers can receive certification credit for professional development courses/programs in Earth and Space Sciences. Officials from 37 states and the District of Columbia responded affirmatively, as long as the teacher teaches science. Officials in 4 states reported that their states would not give recertification credit for Earth and Space Sciences courses/programs. 3 officials stated professional development was a local issue and would be approved by LEAs. It was not possible to collect data for the remaining 6 states.

Figure 4: Number of States Supporting Recertification Credit for Earth/Space Sciences Courses/Programs



b. Does the SEA provide support such as lesson plans and other resources?

While there is no mandated national science curriculum in the United States, all states and the District of Columbia require that certain curriculum standards are used to guide school instruction. As such, all states provide a set of elementary level science standards for school districts, schools, and teachers to use in the planning and development of science curricula, including the geosciences.

For 21 states, the only guidelines for curriculum development in elementary school science are the state’s science standards. The remaining 29 states and the District of Columbia provide additional guidelines for elementary science curriculum development. These resources come in a variety of forms and are described in the following table. All of the resources listed were identified on SEA websites and can be downloaded or accessed by teachers.

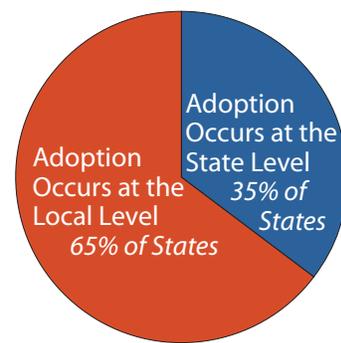
Table 1: Guidelines for Elementary Science Curriculum Development and Number of States

Resource	Description	Number of States
Science frameworks	Identify the key scientific ideas and practices all students should learn.	8
Curriculum maps	Outline the content, skills, assessments, and activities to be administered by teachers.	7
Learning progressions	Provide pathways that students travel as they progress toward mastery of foundational science content and skills.	6
Benchmark maps	Present standards designed to assess student mastery as a result of instruction and to serve as indicators for student success.	5
Templates for unit design	Delineate the key components of a science curriculum unit.	3
Curriculum development guides	Provide a series of steps to follow in creating a curriculum document.	8
Model units	Serve as exemplar curriculum units that teachers can use as models for developing their own curriculum units.	4
Lesson plan templates/guides	Delineate the key components of a science lesson plan.	2
Web-based lesson plan portals	Allow teachers to access science lesson plans that have been developed by educators from the state.	7
Model lesson plans	Serve as exemplar lesson plans that teachers can use as models in the development of their own lesson plans.	3
Assessment guidelines	Provide suggestions for selecting assessment types, examples of assessments, rubrics, and recommendations for implementation.	7

c. Are there instructional programs adopted that address geosciences instruction?

There are two methods used by states in selecting instructional materials (e.g., textbooks, electronic media) for use in their schools. In 32 states and the District of Columbia, instructional material selection occurs at the local level. This means that these states allow Local Education Agencies (LEAs) or schools to choose the published educational programs to be used in the classroom. The remaining 18 states are known as adoption states. These states choose at the state level a selection of instructional materials, and then districts can choose materials from among those to adopt for use by their schools.

Figure 5: Local Level Versus State Level Textbook Adoption



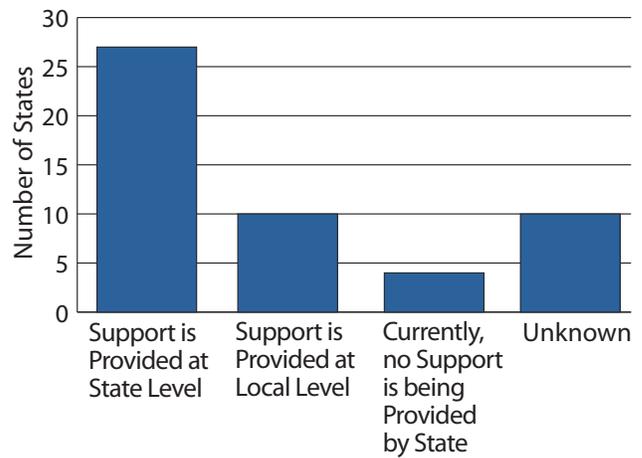
Within adoption states, the names of publishers and the titles of instructional materials approved by the state are made available to the public. For this report, the titles of the published programs adopted for use in elementary science by adoption states were reviewed to determine the extent to which geosciences-related materials are being offered to elementary teachers. 10 states (56% of adoption states) have approved science materials at the elementary level with titles that contain topics specific to the geosciences (e.g., weather, seasons, energy, natural resources, water cycle, minerals and rocks, fossils, land and surface, Sun, and space). The other 8 states (44% of adoption states) have approved science textbooks with titles that do not specify content, (e.g., Science: A Closer Look, Scott Foresman Science, and Discover Education Science). However, for most of these states, textbooks are state specific, (e.g., Science: A Closer Look, Tennessee Edition). Typically, state specific editions are written to address the state’s science standards, and in many cases use state-specific examples. All state standards contain geosciences-related concepts at the elementary level, which would imply that state textbook editions contain geosciences content.

d. Are school systems provided with financial resources to develop their own geosciences materials and/or acquire supplies for instruction?

As stated, the instructional materials available to elementary teachers for science instruction are selected from a range of materials that were screened through an evaluation and adoption process that occurred at either the local level (65% of states) or state level (35% of states). This means that in most cases textbooks or other materials used as basal resources are selected by schools or districts, not necessarily by individual teachers. However, in many cases teachers are mandated to implement their state’s standards, not a textbook or other adopted program. As a result, teachers vary considerably in the way they use instructional materials, with some teaching strictly according to the materials they are given and others exercising considerable flexibility. If there are changes to the standards, then the instructional materials being used may not be aligned to the new standards. For teachers who teach directly according to the materials they are given, this can be problematic. For teachers who develop their own lessons, the impact might be less pronounced. Only after the state or district has gone through a textbook adoption process with the new standards in place do instructional materials become aligned, once again, to the standards.

While the state develops the standards, ultimately, it is districts, schools, and teachers who are responsible for the curriculum that is implemented and its adherence to the standards. For this report, SEA officials were asked the extent to which the state is able to provide school systems the resources they need to effectively implement the standards as they change. 27 officials stated that their states provide mechanisms to support teachers with the implementation of new standards. This support comes mainly in the form of workshops and professional development courses, but may also include curriculum development guidance, such as the specific guidelines for elementary science curriculum development discussed in subsection b. 10 officials stated that standards implementation and curriculum development is a local decision and districts develop resources for addressing changes to the standards. 4 officials stated that their states are not offering any support mechanisms at this time. For the remaining 9 states and the District of Columbia the data could not be collected.

Figure 6: Resources Provided to Address Changing Standards



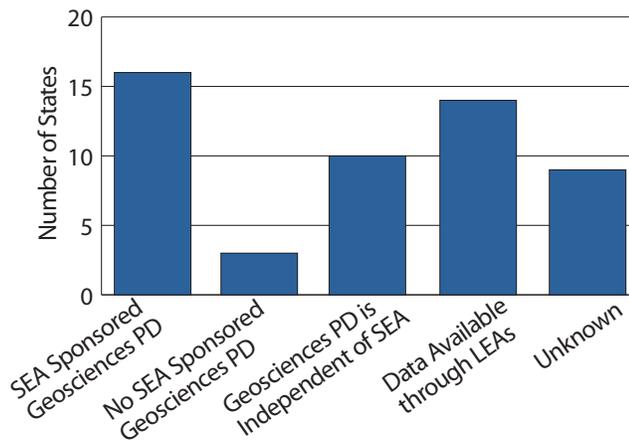
e. Does the SEA provide professional development that is, at least in part, specific to the geosciences? (e.g., GLOBE Program, Project WET, Project WILD)

Professional development (PD) of teachers comes in many forms and at various points throughout teachers’ careers. In some states, districts choose their own PD policies. In these places, the state plays a limited role and provides little support or information to districts, allowing them to make their own PD decisions. In other places, the state serves as the central agency for PD information, but allows districts to choose their own strategies. In some cases, the state dictates the specific aspects of its districts’ PD and continuing education programs for teachers.

SEA officials were asked whether the SEA provides PD that is, at least in part, specific to the geosciences. 16 officials reported that the SEA is involved, in some way, in the delivery of PD programs pertaining to geosciences-related curriculum and instruction. The extent of this involvement varies extensively. In some states the SEA supports regional educational centers that offer geosciences-related PD. In other states, the SEA provides grants to informal science organizations that provide PD in the geosciences. Certain states offer institutes focusing on the geosciences that offer graduate-level course credit. In some cases, the SEA hosts a PD website that provides on-line geosciences-related courses. A number of states support PD programs in the geosciences through a combination of approaches.

For the remaining states, 14 officials stated that PD training pertaining to geosciences curriculum or instruction is determined at the local level and LEA officials would have to be contacted for more information. 3 officials reported that the SEA provides PD training, however, at the time, none was being offered that was geosciences related. 10 officials described geosciences-related PD as possibly occurring independently of the SEA (e.g., through Departments of Natural Resources, Environment, and Parks, or through informal science organizations such as museums and science teacher associations). For 8 states and the District of Columbia data could not be collected.

Figure 7: **SEA Sponsored Professional Development Programs Pertaining to the Geosciences**



Findings: Curriculum

2. What evidence is there that there has been conscientious thought given to what is to be taught to students with respect to the geosciences?

a. What is the organization of the standards? To what extent do standards have geosciences separate from other sciences, or are they combined?

The No Child Left Behind (NCLB) Act, a reauthorization of the Elementary and Secondary Education Act, was signed into law in January, 2002. Regarding science education, the NCLB Act required all states to develop challenging content standards for science by the 2005–06 school year. At the time of writing, all 50 states and the District of Columbia maintain science standards at the elementary, middle, and secondary levels.

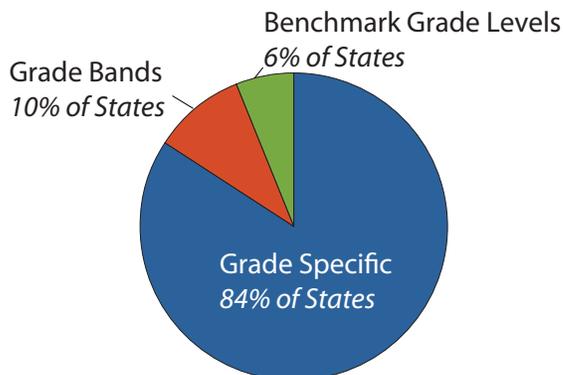
While mandated to develop science standards, states were given flexibility in the design of their standards. At a minimum, the standards are required to do the following:

- “Specify what children are expected to know and be able to do”
- “Contain coherent and rigorous content”
- “Encourage the teaching of advanced skills”³

As a result of the flexibility given to states in the development of their science standards, there are a number of ways in which state standards are structured. For the purposes of this report, each state’s science standards were analyzed to determine patterns in the systematic presentation of geosciences concepts at the elementary level.

First, the arrangement of standards at the grade-level was examined. 42 states and the District of Columbia provide grade-specific standards (i.e. separate standards for each grade K through 5). In 5 states, the standards are organized by grade level bands (e.g., K-2 and 3-5). The standards for the remaining 3 states are organized by benchmark grade levels (e.g., grades 4, 8, and 11).

Figure 8: **Grade Level Organization of Elementary Science Standards**

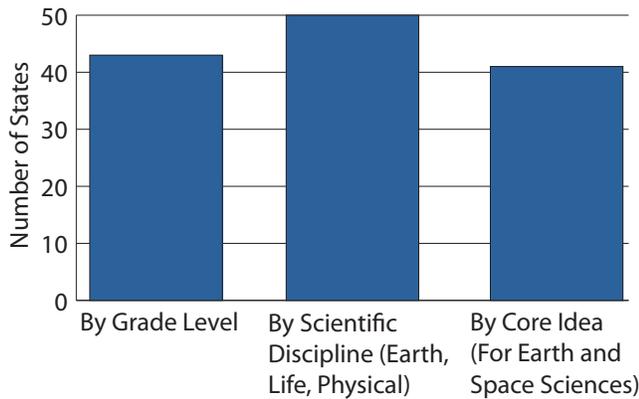


Next, the standards were reviewed to determine the extent to which they are grouped according to science discipline. 49 states and the District of Columbia include standards that are subdivided, at each grade level, grade-level band, or benchmark grade level according to the scientific disciplines: Physical Sciences, Life Sciences, and Earth and Space Sciences. West Virginia’s “21st Century Science K-8 Content Standards and Objectives for West Virginia Schools” is the only state standards that do not subdivide content standards by scientific discipline. However, in 2016, West Virginia will begin implementation of the newly adopted “Next Generation Content Standards and Objectives for Science in West Virginia Schools.” The content standards within this document are organized by scientific discipline.

After this, the Earth and Space Sciences standards were examined to determine the extent to which they are subdivided by certain core ideas in the geosciences (e.g., structure of the Earth, Earth history, Earth’s systems, Earth in the solar system, weather, natural resources, and Earth materials). 40 States and the District of Columbia subdivide specific Earth and Space Sciences standards by core idea. The remaining 10 states provide their standards in list form without core idea categorization.

³ Learning Point Associates. (2007). *Understanding the No Child Left Behind Act: Mathematics and Science*. Retrieved April 17, 2015 from www.learningpt.org/pdfs/qkey4.pdf

Figure 9: Subdivision of State Science Standards



b. How are the ideas to be taught outlined (e.g., objectives, outcomes, performance indicators)?

Generally, each state’s standards describe the knowledge and skills students are expected to possess after instruction. The focus of this report is what students learn within the context of elementary school science, which includes geosciences-related content. All states and the District of Columbia present their elementary science standards as statements that define what students are expected to know and/or be able to do at various points. However, the details of those standards are varied.

For 29 states, the standards are presented on two levels, beginning with broad overarching standard statements that apply to either multiple grade levels or to a single grade. For the majority of states, these statements are known simply as the “Standards”, “Content Standards”, or “Content Statements”. These standards are then defined further by sub-standard statements, which typically apply to a single grade, but may apply to a grade level band (e.g., K-2), or a benchmark grade level (e.g., 4 and 8). The sub-standards explain what students are expected to know and be able to do to demonstrate an understanding of the overarching standards. States identify these statements by a variety of names.

Table 2: Terms for Sub-Standards in State Standards

Sub-Standard Nomenclature	States
Benchmarks	Florida, Hawaii, Louisiana, Minnesota, Montana, Wyoming
Benchmark Expectations	North Dakota
Clarifying Objectives	North Carolina
Content Expectations	Michigan
Content Elaboration	Ohio
Content Standards and Supporting Skills	South Dakota
Evidence Outcomes	Colorado
Grade-Level Expectations	Connecticut, Missouri, Tennessee
Grade Span Expectations	New Hampshire
Grade Band Standards	Nebraska
Indicators	Indiana
Learning Expectations	Arkansas
Objectives	Mississippi, Utah, Idaho
Performance Indicators	New York, South Carolina
Performance Indicators and Descriptors	Maine
Performance Objectives	Arizona
Performance Standards	Alaska, Georgia, New Mexico

For 7 states, there are no overarching standard statements. Rather, the standards, called Content Standards (Alabama), Standard Statements (Pennsylvania), Standards (Virginia), Essential Concepts and/or Skills (Iowa), Learning Standards (Massachusetts), Essential Knowledge and Skills (Texas), Performance Standards (Wisconsin) are presented as what students are expected to know and be able to do upon the completion of a grade band (MA), benchmark grade (WI), or grade-level (AL, PA, VA, IA, TX).

The same is true for the District of Columbia and the 13 states that have adopted the nationally developed Next Generation Science Standards (NGSS) (California, Delaware, Illinois, Kansas, Kentucky, Maryland, Nevada, New Jersey, Oregon, Rhode Island, Vermont, Washington, and West Virginia), which were released in April, 2013. For these states, Performance Expectations describe what students should know and be able to do.

Similarly, Oklahoma has developed its standards based on the NGSS, and also provides them as Performance Expectation statements.

c. To what extent are students encouraged/ guided to investigate current issues in the geosciences?

The elementary standards for all states and the District of Columbia were examined to determine the extent to which they require that teachers include current issues in the geosciences in their instruction. For this purpose, current issues in the geosciences can be described as Earth science processes altered by human activities or Earth science processes that affect human well-being. For the former, topics include energy resources, climate modification, waste disposal, and mining resources. Topics for the latter involve natural hazards, such as earthquakes, flooding, and tornadoes. 43 states and the District of Columbia include current issues in the geosciences in their elementary standards, while 7 states do not.

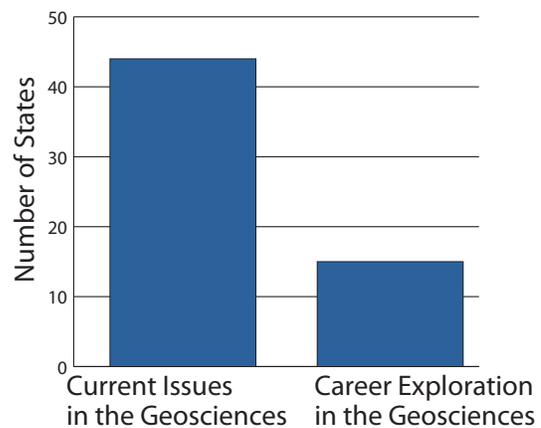
d. To what extent is information about geosciences-related careers intentionally included in instruction?

The elementary standards for all states and the District of Columbia were examined to determine the extent to which teachers are required to address geosciences-related careers in their instruction. 35 states and the District of Columbia do not place any emphasis in their elementary science standards on career options/career exploration in the field of geosciences. The following table lists the 15 states that do have standards that relate to geosciences careers and the grade levels at which those standards are to be addressed.

Table 3: States Requiring Instruction that Addresses Career Options in the Geosciences

State	Grade(s)
Arizona	2-4
Arkansas	5
Georgia	3-5
Maine	K-5
Minnesota	3
Montana	5
New Hampshire	K-4
New Mexico	4
North Dakota	3- 4
Ohio	K-5
Oklahoma	K
Texas	3-5
Virginia	K-5
West Virginia	2-5
Wisconsin	4

Figure 10: State Science Standards and Current Issues and Career Exploration in the Geosciences



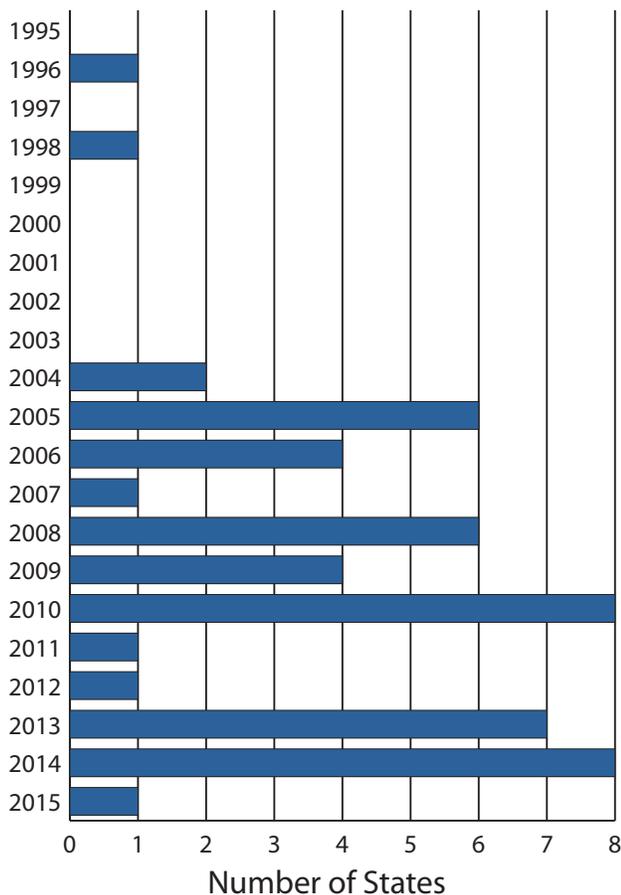
e. When were the standards last reviewed/ revised?

Historically, states have adopted academic standards for science instruction that they developed themselves, or they may use nationally developed standards (e.g., the National Science Education Standards or the NGSS) with more or less alteration. In either case, a state conducts a review and revision process before it formally adopts

its academic standards. This is typically carried out by teams of educators, administrators, education officials, and education partners. Additionally, a state will often make additional improvements and additions to the standards after they have been reviewed by the public. The timelines for reviewing and revising standards vary from state to state, but can take several years.

For this report, the adoption date or latest revision date of each state’s elementary science standards was collected. These dates are used as an indicator for when the standards were last reviewed and/or revised. 8 states adopted their standards within the last 2 years. 18 states and the District of Columbia adopted their standards in a range of 3 to 6 years ago (2010-2013). 16 states adopted their standards in a range of 7 to 10 years ago (2006-2009). 10 states adopted their standards more than 10 years ago (before 2006). It should be noted that two states split the adoption dates of their elementary standards (PA: K-3 and 3-8; UT: K-2 and 3-6).

Figure 11: State Adoption of Science Standards by Year

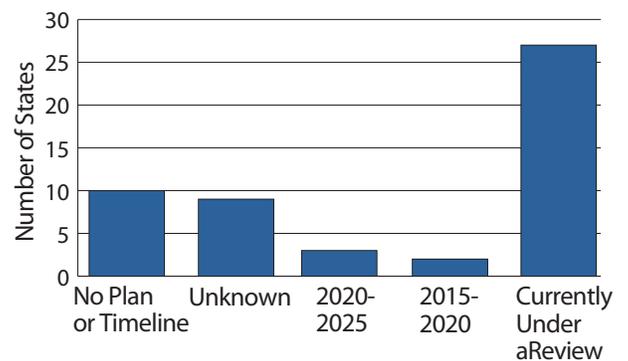


f. How often are the standards reviewed?

Most states are mandated by state legislation to periodically review their standards for quality and adherence to current research and academic advances. If a state considers its standards in need of improvement, it may revise its current standards, develop new standards, or consider adoption of other standards. Each option can be costly and if a state is not able to budget for such a task, it may postpone the development and revision process until resources become available.

For this report, SEA websites were reviewed and SEA officials were interviewed for information about future plans to review/revise the state science standards. 10 states are currently undergoing a review process of their standards. 5 states will be reviewing/revising their standards in 2015. 4 states will be reviewing/revising their standards in 2017. 1 state will be reviewing/revising its standards in 2021 and 1 state in 2022. The remaining 27 states and the District of Columbia currently have no specific plans for revision or a timeline for revision has not been set. It should be noted that some of these states only recently completed a review/revision and adoption process. For 2 states the data could not be collected.

Figure 12: Timeframes for Revising State Science Standards



Findings: Instruction

3. What evidence is there that the approaches to instruction that are promoted for use with respect to geosciences topics are given conscientious consideration?

a. What specific instructional approaches are promoted to teachers in a coherent manner? (e.g., 5E learning cycle, use of kits that include inquiry activities, problem-based learning)

As discussed in the Teacher Preparation section, all states provide a set of elementary level science standards for school districts, schools, and teachers to use in the planning and development of science curricula, including the geosciences. As reported in the same section, the standards are the only guidelines provided by the state for curriculum development in elementary school science for 21 states (41%). The remaining 30 states (59%) provide a variety of additional guidelines for elementary science curriculum development.

The standards and additional science guidelines for each state were reviewed to determine the extent to which teachers are being encouraged to use specific approaches to instruction of science topics at the elementary level. For this purpose, instructional approaches can be described as the methods or strategies that teachers may take to actively engage students in the learning of science content. These strategies are designed to guide the approach taken in a teacher's instruction as he/she works to meet specific learning objectives.

It was found that the state elementary science standards for all states and the District of Columbia provide certain guidelines regarding the approaches to be used for science teaching. For 35 states, an "inquiry-based" approach to learning science is promoted. For the remaining 16 states, which include the District of Columbia and the 13 states that have adopted the Next Generation Science Standards, an approach is promoted that includes the use of "Science and Engineering Practices". Collectively, therefore, some manner of active investigation is intended for K-5 science instruction throughout the United States.

Table 4: Approaches to Learning Science Promoted in State Elementary Science Standards

Name of Approach	State
Inquiry	FL, NE, NM
Inquiry-Based	IN
Inquiry-Based Learning	AL, GA
Inquiry-Based Instruction	MA
Inquiry Process	AZ, MI
Inquiry and Process Skills	AR
Science Inquiry	HI, WI
Science as Inquiry	AK, IA, LA, NC, ND, PA, TX, WY
Scientific Inquiry	CT, ID, ME, MS, MO, MT, NH, NY, OH, SD, TN, VA
Scientific Inquiry and Investigation	MN
Scientific Inquiry and Scientific Process Skills	CO
Student Inquiry	UT
Science and Engineering Practices	CA, DE, DC, IL, KS, KY, MD, NV, NJ, OK, OR, RI, SC, VT, WA, WV

In addition to the general guidance regarding inquiry-based approaches and the use of Science and Engineering Practices, 8 states advocate more specific strategies for science instruction in their guidelines for science. 5 states (Alabama, Alaska, Arizona, Maryland, and Ohio) suggest some version of the "5E Learning Cycle" as the instructional model.⁴ 3 states (Florida, Kentucky, and Oregon) recommend a range of approaches (listed in the following table). In each case these are intended to facilitate active science investigation by students.

⁴ Trowbridge, L.W., and R.W. Bybee. (1990). *Becoming a Secondary Science Teacher*. Columbus, Ohio: Merrill.

Table 5: States that Suggest Approaches to Instruction, in Addition to Inquiry

State	Suggested Instructional Approach
Florida	Each lesson plan offered on CPALMS, FL’s on-line toolbox includes an “Instructional Design Framework(s)” section that describes the lesson’s approach to instruction. Approaches listed include: conformation inquiry, structured inquiry, guided inquiry, open inquiry, direct instruction, demonstration, cooperative learning, learning cycle, writing to learn, and argumentation.
Kentucky	The “Model Curriculum Framework, 2014” serves as a guide in selecting instructional resources that are aligned to the standards. Instructional models suggested for use include: Making Connections to Prior Learning and Experiences, Universal Design for Learning, Differentiation, Teaching as Inquiry, and E-Learning.
Oregon	The “Science Teaching and Learning to Standards” guide provides resources and advice for teachers to help them implement the state’s standards. Scientific inquiry teaching models suggested for use include: K-W-L model (what you know, what you want to know, and what you’ve learned), Learning Cycle model, and Design Space idea.

b. What is the relationship between instructional approaches that are promoted for use with respect to the geosciences and the standards?

As stated in the previous sub-question (sub-question 3a.), all state elementary standards suggest an active investigation-based approach to the learning of science concepts, which includes the geosciences.

c. What justification is given for why these approaches are promoted? To what extent is the rationale specific to the nature of the geosciences?

The standards and science guidelines for each state were reviewed to determine the extent to which states provide a rationale for using particular approaches to learning elementary science, which includes the geosciences. It

was found that 14 states provide no rationale. For these states, standards and guidelines describe the skills students should apply in the classroom, but give no justification for why these skills promote understanding of science concepts. 13 states and the District of Columbia have adopted the Next Generation Science Standards (NGSS) and 2 states have based their standards on the NGSS. These states follow the rationale provided in the NGSS for the use of Science and Engineering Practices, which includes the following justification:

“Engaging in the practices of science helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the wide range of approaches that are used to investigate, model, and explain the world. Engaging in the practices of engineering likewise helps students understand the work of engineers, as well as the links between engineering and science. Participation in these practices also helps students form an understanding of the crosscutting concepts and disciplinary ideas of science and engineering; moreover, it makes students’ knowledge more meaningful and embeds it more deeply into their worldview.”⁵

For the remaining 21 states, the most commonly shared rationale for following an inquiry-based/investigation approach is similar to that provided in the NGSS. Simply put, this rationale suggests that students learn best when they are allowed to build their understanding of scientific concepts using methods and thinking processes that parallel the work and construction of knowledge by practicing scientists.

⁵ NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States (Appendix F – Science and Engineering Practices in the NGSS)*. Achieve, Inc. on behalf of the twenty-six states and partners that collaborated on the NGSS. Retrieved April 17, 2015 from <http://www.nextgenscience.org/next-generation-science-standards>

Table 6: Example Rationales for Inquiry-Based Approaches to Teaching Science

State	Rationale
Alabama	“Effective science instruction emphasizes critical thinking and investigative processes that reveal consistencies, relationships, and patterns. The science laboratory, therefore, should be thought of as any place where scientific inquiry occurs, whether it be the traditional laboratory, classroom, playground, science museum, amusement park, or beach.” ^{T1}
Arizona	“Science as inquiry is basic to science education and a controlling principle in the continuing organization and selection of students’ activities. Students at all grade levels and in every domain of science should have the opportunity to use scientific inquiry and develop the ability to think and act in ways associated with inquiry.” ^{T2}
Hawaii	“Scientific investigation is about the wonder of discovery, the pride of invention, and the satisfaction of increasing knowledge about the world. Students use science inquiry skills that are part of a process to answer a question or satisfy a curiosity. These steps or skills help students understand and support their discoveries.” ^{T3}
Kentucky	“As a result of participating in inquiries, learners will increase their understanding of the science subject matter investigated, gain an understanding of how scientists study the natural world, develop the ability to conduct investigations, and develop the habits of mind associated with science.” ^{T4}
Massachusetts	“Engaging students in inquiry-based instruction is one way of developing conceptual understanding, content knowledge, and scientific skills. Scientific inquiry as a means to understand the natural and human-made worlds requires the application of content knowledge through the use of scientific skills.” ^{T5}
Mississippi	“Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop an understanding of scientific ideas, as well as an understanding of how scientists study the natural world.” ^{T6}

State	Rationale
Montana	“Science is an inquiry process used to investigate natural phenomena, resulting in the formation of theories verified by directed observations. Inquiry challenges students to solve problems by observing and collecting data and constructing inferences from those data. In doing so, students acquire knowledge and develop a rich understanding of concepts, principles, models, and theories.” ^{T7}
Pennsylvania	“Understanding of science content is enhanced when concepts are grounded in inquiry experiences. The use of scientific inquiry will help ensure that students develop a deep understanding of science content, processes, knowledge and understanding of scientific ideas, and the work of scientists; therefore, inquiry is embedded as a strand throughout all content areas.” ^{T8}
Wisconsin	“Students should experience science in a form that engages them in actively constructing ideas and explanations and enhances their opportunities to develop the skills of doing science. Such inquiry (problem solving) should include questioning, forming hypotheses, collecting and analyzing data, reaching conclusions and evaluating results, and communicating procedures and findings to others.” ^{T9}
Wyoming	“Inquiry is the foundation for the development of content and processes of science that enable students to construct their own knowledge. This standard addresses students’ ability to safely conduct investigations and develop an understanding of inquiry, enriching their knowledge of science. The Science as Inquiry Standard emphasizes the process of confronting accepted ideas and gaining new information through research and investigation.” ^{T10}

Table 6 footnotes (T1-T10)

- 2004-2005 Science State Course of Study Committee and Task Force. (2005). *Alabama Course of Study: Science* (Bulletin 2005, No. 20). Retrieved April 17, 2015 from <http://www.alsde.edu/sec/sct/Pages/cos-all.aspx?tab=All%20Stds/COS>
- Science Standard Revision Committee. (2004). *Arizona Science Standards Articulated by Grade Level*. Retrieved April 17, 2015 from <http://www.azed.gov/standards-practices/academic-standards/science-standard/>
- Hawaii Commission on Performance Standards. (2005). *Hawaii Content and Performance Standards III*. Retrieved April 17, 2015 from <http://165.248.72.55/hcpsv3/library.jsp>

d. What kinds of technology are used to present content?

Advances in computer technology and the rich array of educational software now available have reformed the use of technology in the classroom. For this report, SEA officials were asked to describe the kinds of technology being used by elementary teachers in their states to present science content to students. 41 officials responded that the incorporation of technology in the classroom is a local decision and the kinds of technology being used vary widely from district to district. 12 of these officials provided examples to demonstrate this variability. 6 officials did not state explicitly that technology is a local decision, but rather reported examples of technology one might find in schools in the state. For 4 states the data could not be collected.

In total, 19 officials provided examples of technology being used, at various levels, in elementary classrooms throughout their states. These include: desktop computers, scientific computer modeling software, 3D printers, probeware, weather stations, electronic tablets (e.g., iPads), mobile lap top carts, probe ware, interactive white boards, web-accessed videos, animations, and graphics, and online simulations.

Table 6 footnotes (T1-T10) continued

- ⁴ Kentucky Department of Education. (2014). *Inquiry*. Retrieved April 17, 2015 from <http://education.ky.gov/curriculum/sci/Pages/Inquiry-MS.aspx>
- ⁵ Massachusetts Department of Education. (2006). *Massachusetts Science and Technology/Engineering Curriculum Framework*. Malden, MA. Retrieved April 17, 2015 from <http://www.doe.mass.edu/frameworks/current.html>
- ⁶ Mississippi Department of Education. (2010). *2010 Mississippi Science Framework*. Retrieved April 17, 2015 from <http://www.mde.k12.ms.us/curriculum-and-instruction/science/2010-mississippi-science-framework>
- ⁷ Montana Office of Public Instruction. Accreditation Division, Curriculum and Instruction Unit. (2010). *Science Content Standards Framework*. Helena, MT. Retrieved April 17, 2015 from <http://www.opi.mt.gov/Curriculum/science/index.php>
- ⁸ Pennsylvania Department of Education. (2009). *Academic Standards for Science and Technology and Engineering Education*. Retrieved April 17, 2015 from <http://www.pdesas.org/Standard/StandardsDownloads>
- ⁹ Wisconsin Department of Public Instruction. (1998). *Wisconsin's Model Academic Standards for Science*. Retrieved April 17, 2015 from http://standards.dpi.wi.gov/stn_sciintro
- ¹⁰ Wyoming Department of Education. (2008). *Wyoming Science Content and Performance Standards*. Cheyenne, Wyoming. Retrieved April 17, 2015 from <http://edu.wyoming.gov/educators/standards/science/>

Findings: Learning Contexts

4. What evidence is there that the contexts in which children learn geosciences topics are well suited to help students learn geosciences topics?

a. What are typical class sizes? What is the range?

Class size is considered by many to have an impact on teaching and learning. While some researchers have not found a strong connection between smaller classes and higher student achievement, it is generally thought that student achievement rises as class size drops.⁶

The average and the maximum allowable number of students in elementary classrooms in each state were researched through reviews of SEA websites and interviews with SEA officials. The reporting of these data was mixed. For 18 states, these data are collected at the district level and not available or reported to SEA officials. For 8 states and the District of Columbia, officials provided a range for the average number of students in an elementary classroom. 6 state officials reported the average number of students in elementary classrooms as an exact number. Officials from 3 states reported a range for the maximum number of students allowed in an elementary classroom. 5 officials reported an exact number for the maximum allowable classroom size. For 11 states the data could not be collected.

⁶ Hyunkuk Cho, Paul Glewwe, Melissa Whitler. (2012). Do reductions in class size raise students' test scores? Evidence from population variation in Minnesota's elementary schools. *Economics of Education Review*, v31 n3, 77-95.

Table 7: Reported Number of Students in Elementary Schools

State	Average	State	Maximum
Connecticut	18-21	Alabama	22-24
District of Columbia	20-25	New Jersey	23-25
Florida	15-18	New Mexico	21-24
Indiana	20-30	Alaska	30
Missouri	15-22	Arkansas	25
New Hampshire	18-20	Delaware	20
North Carolina	15-22	Georgia	33
North Dakota	18-20	West Virginia	25
Wyoming	18-22		
Georgia	23		
Iowa	22		
Ohio	25		
Rhode Island	20		
South Carolina	16		
Vermont	22		

b. What is the general expectation as to the time that will be devoted to geosciences instruction? At what level is this defined (SEA, state, district, teacher)?

As described in the Curriculum Findings section, all states and the District of Columbia maintain standards mandating that science be taught at the elementary level. Moreover, the standards for all states and the District of Columbia require teachers to address concepts related to the Earth sciences, life sciences, and physical sciences.

SEA officials were asked whether elementary teachers in the state are required to dedicate a certain amount of instructional time to science. 18 officials responded that there is no time requirement for teaching science at the elementary level. 23 officials reported that instructional time requirements are determined at the local level. 5 officials reported that, in their states, it is recommended or mandated that teachers spend a specified amount of time teaching science. For 5 states the data could not be collected.

Table 8: States with Time Requirements for Science Instruction at the Elementary Level

State	Requirement
Connecticut	Equity must be provided for reading, math and science.
District of Columbia	45 minutes daily
Missouri	45 minutes daily
Nebraska	Each elementary school must have on file a representative weekly schedule for each classroom teacher encompassing experiences in reading and language arts, mathematics, social studies, science, health, physical education, art, and music.
Wisconsin	Kindergarten: 10% Grade 1-2: 100 minutes per week Grade 3-4: 150 minutes per week Grade 5: 175 minutes per week

c. If a child has an IEP or ILP, how might that affect the learning of geosciences? (e.g., Are ESL or ILP students pulled out of science class on a repeated basis?)

Students who do not achieve expected competencies in certain academic areas may receive different kinds of instructional assistance, depending upon the issues affecting their learning. English as a Second Language (ESL) support may be available for students who are recent immigrants or for whom English is not the primary language in the home. Students with delayed skills or other disabilities might be eligible for special education services. Special Education services will be outlined in an Individualized Education Program (IEP) and ESL accommodations are described in an Individual Learning Plan (ILP) that education professionals develop for each student.

The specialized support and services provided to students with IEPs or ILPs is designed to help them build essential skills and achieve educational goals and objectives. Assistance may include classroom accommodations and modifications. In some states, students with IEPs or ILPs are removed at certain times from the classroom for one-on-one or group work with a specialist (sometimes called “pull out” programs). When this occurs, students may miss classroom instruction, most often in academic areas such as science, history, and

specials. At other times the specialist will work with the child during classroom instruction (e.g., in “co-teaching” or “push in” models).

SEA officials were asked to describe the extent to which the assistance provided to students with IEPs or ILPs has an impact on the learning of geosciences in the classroom, including the pulling out of these students during science instructional time.

23 officials stated that in their states decisions regarding students with IEPs or ILPs are carried out at the local level and more information regarding common practices for supporting these students would have to be obtained from districts and schools. Officials from 17 states and the District of Columbia reported that support mechanisms, such as classroom accommodations or pull-out services, vary widely, depending on the specifications of IEPs or ILPs. 1 official (Florida) reported that students with IEPs or ILPs are not pulled out during science. 2 officials (Kansas and Virginia) reported that in their states pull-out services for students with IEPs or ILPs typically occur during science instruction. For 7 states the data could not be collected.

Table 9: States Reporting Policies on Services for Students with IEPs or ILP

State	Policy (Reported by SEA Official)
Florida	Students are pulled out from specials and not from content classes like science.
Kansas	Students are typically provided services during time allotted to science.
Virginia	If science is taught, students are usually pulled out of science for services. Specialist teachers have received professional development in teaching science concepts.

Findings: Extra-Curricular Programs

5. To what extent do children have access to extra-curricular and co-curricular opportunities to learn geosciences?

a. What kinds of geosciences-related opportunities are available to students beyond the classroom (e.g., through academic clubs, after school programs, and informal education networks)?

Enrichment opportunities beyond the classroom come in many forms. For example, many school districts across the United States provide afterschool programs that offer an array of educational and recreational activities to students during after-school hours. Participation in these programs is voluntary and many are fee-based. In recent years, the benefits of quality afterschool programs have been realized and participation in these programs has grown. In 2009, an estimated 4 million students were enrolled in formal after-school programs at public elementary schools in the United States.⁷

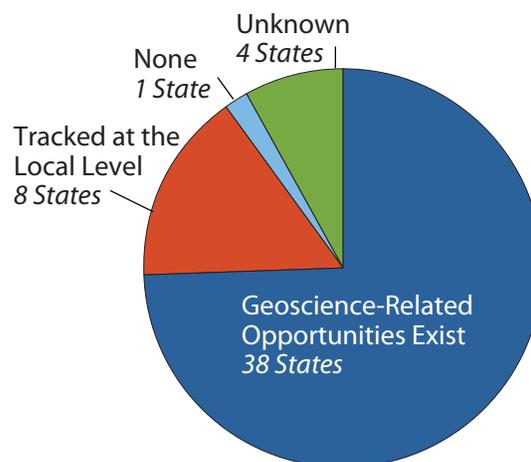
Formal education is classroom-based and is generally provided by certified teachers. Informal education typically happens outside the classroom in museums, libraries, or other locations that most often are attended voluntarily. On the contrary, attendance at formal education settings tends to be mandatory, and teachers are expected to implement a curriculum that meets certain standards, whereas informal education programs can be more flexible with their content. Classrooms have the same students and teachers over a period of time, while attendance in informal programs may be inconsistent and the staff may change more frequently, often from day to day.

SEA officials were asked to describe opportunities beyond the classroom in which elementary students in their states engage in geosciences-related topics. Officials from 37 states and the District of Columbia were able to provide some description of programs or organizations with possible geoscience-related activities being offered to students in their states. The range of

⁷ U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics. (2009). *After-School Programs in Public Elementary Schools, First Look*. Retrieved April 17, 2015 from <http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2009043>

enrichment opportunities was wide and included geosciences-related clubs, the GLOBE program, Project WET, Project WILD, NASA Kids, and Project Learning Tree. Additionally, many officials described public, private, and non-profit organizations conducting geosciences education initiatives, such as museums, planetariums, aquariums, science centers, zoos, universities, natural resources and environmental agencies, as well as state and national parks. Officials from 8 states stated that they had no information because such programs and opportunities are organized and tracked at the local level. One official stated that no such programs exist. The data for 4 states was unable to be collected.

Figure 13: States with Geosciences-Related Extra-Curricular Opportunities



b. What remedial supports are in place for geosciences topics with which students are struggling?

The aim of remedial education is to provide learning support to students who lag far behind their counterparts in school performance. Whereas IEP support is designed specifically for students with special needs as a result of identified factors that affect learning, remedial education can be designed for any students, with or without special needs.

Remedial education services can take many forms. Sometimes, students are given individualized basic skills instruction. In other cases, teachers adapt the school curricula and teaching strategies to provide learning activities to students that meet their needs.

SEA officials were asked to describe the remedial support systems provided by schools and districts to help

elementary students struggling in science. 35 officials stated that decisions regarding remediation are made at the local level and the SEA did not have any relevant data. 5 officials reported that their states are required to provide remediation services to students in science and they provided a general description of that support. Officials from 2 states and the District of Columbia stated that there is no remediation support for students in elementary science. For 8 states the data could not be collected.

Table 10: Five States Reporting Remediation Support in Elementary Science

State	Description of Remedial Support (Reported by SEA Official)
Arkansas	Students are required to receive remediation services if they do not perform satisfactorily on the 5th grade assessment.
Delaware	Students are provided differentiated instruction to meet their needs.
Florida	Remediation is required for science. Districts use Gizmo, an online science simulation program for struggling science students.
New York	Schools must provide Academic Intervention Services to students who have failed or are at risk of failing.
West Virginia	Through Support for Personalized Learning initiatives, students with difficulty in all subject areas are addressed.

Findings: Monitoring Systems

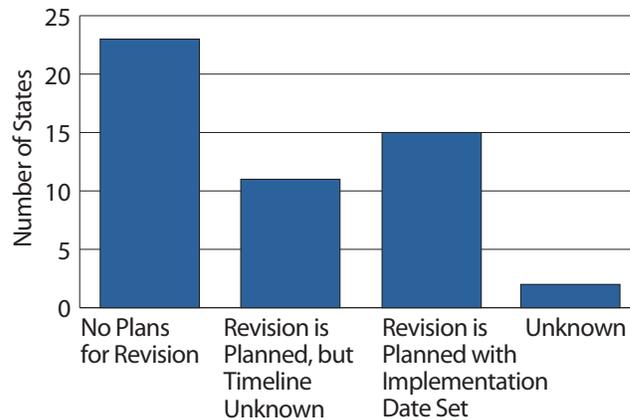
6. To what extent is student learning in the geosciences monitored?

a. What is the relationship between the monitoring system(s), instructional approaches that are promoted for the geosciences, and standards?

In addition to mandates for the development of state standards, the No Child Left Behind (NCLB) Act set out several new requirements for student assessments. At the elementary level, the Act required that states implement annual assessments in mathematics and reading or language arts for Grades 3-8 beginning in the 2005-06 school year. It also required that annual tests in science be administered not less than one time during Grades 3-5 beginning in the 2007-2008 school year. In addition, science assessments had to be aligned to state standards.⁸

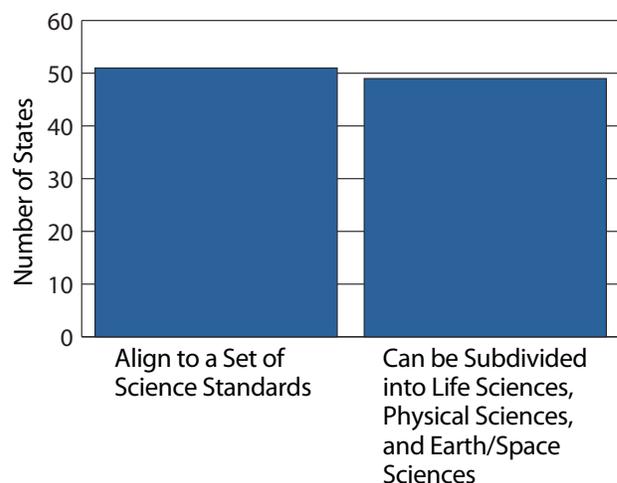
At the time of writing, every state and the District of Columbia has met the requirements for elementary science and maintains a statewide science assessment that is aligned to a set of state science standards (i.e. measures achievement of the standards). However, for a number of states, new standards were recently adopted (e.g. the Next Generation Science Standards), or a state may have recently revised its standards. For some of these states, the science assessment is aligned to an older set of standards. To better understand the extent to which the development of assessments is in flux, state websites were reviewed and state officials were asked to describe any planned changes to their state's elementary science assessment. 23 states do not have any plans in place for revising or changing their current elementary level science assessment. 10 states and the District of Columbia will be changing their assessments, but a timeline for revision is not in place. 15 states have revised their assessments, or are in the process of revising, with a future date set for implementation. The data for 2 states was unable to be collected.

Figure 14: **Revision Plans for Statewide Elementary Level Science Assessments**



For this report, test blueprints, test item specification documents, and science assessment technical reports were reviewed from each state to determine the content of the elementary science assessments. 48 states and the District of Columbia currently administer exams that contain questions measuring students' knowledge of all three scientific discipline areas, namely, Physical Science, Life Science, and Earth/Space Science. For these states, the number of items, distribution of points, or percentages of the exam that address each science discipline can be identified. Only 2 states (Kansas, and West Virginia) do not identify the content of their elementary assessments by science discipline.

Figure 15: **Characteristics of Statewide Elementary Level Science Assessments**



⁸ Learning Point Associates. (2007). *Understanding the No Child Left Behind Act: Mathematics and Science*. Retrieved April 17, 2015 from www.learningpt.org/pdfs/qkey4.pdf

b. Are student scores on geosciences assessments reported at the district level? What are they?

The No Child Left Behind (NCLB) Act also set out several new requirements for reporting on student achievement on statewide assessments. The Act requires states to develop Performance Level Descriptors (PLDs) that define a student’s performance on the assessment. The PLDs should be organized into distinct levels that describe the content and processes that a student at a given level is expected to know, demonstrate, or perform. At a minimum, there should be three levels of achievement: basic, proficient, and advanced.⁹ Only 9 states measure student achievement according to the three minimum levels. 34 states and the District of Columbia maintain four levels of achievement (e.g., below basic, basic, proficient, and advanced). The remaining 7 states measure student achievement according to five levels (e.g., novice, below mastery, mastery, above mastery, and distinguished).

For all states, the PLDs are to provide a student’s general conceptual understanding of science content and the application of scientific processes. This means that, at a specific performance level, a student must demonstrate the performance described at that level. As such, each level of achievement is typically written as an overall understanding of the Life Sciences, Physical Sciences, and Earth/Space Sciences.

⁹ Learning Point Associates. (2007). *Understanding the No Child Left Behind Act: Mathematics and Science*. Retrieved April 17, 2015 from www.learningpt.org/pdfs/qkey4.pdf

Figure 16: Sample PLDs – Missouri Assessment Program (MAP) Science Grade 5

**PLDs – Missouri Assessment Program (MAP)
Science Grade 5**

Below Basic
Students identify the relationship between mass and force; classify bodies of water; identify weather instruments and their uses; identify characteristics of the solar system; compare amounts/measurements given in a simple format; identify appropriate tools for simple scientific measurements; identify how technological advances may be helpful to humans.

Basic
Students explain the relationship between mass and force; describe how specialized body structures help animals survive; match environments to the plants and animals they support; identify environmental problems and find solutions; construct part of a graph; determine the appropriate scientific tool and its function in an investigation; determine how technological advances address problems and enhance life.

Proficient
Students describe changes in properties of matter; identify uses of simple machines; explain how work is done; identify forces of magnetism; describe the motion of objects; identify plant parts and their functions; classify vertebrates and invertebrates; classify producers, consumers, or decomposers; predict changes in food chains; identify the effects of human activities on other organisms; describe the Sun as a source of light and heat, or the moon as a reflector of light; explain the day/night cycle; identify characteristics and variables of a fair test; interpret data and make predictions; draw conclusions based on evidence; distinguish between man-made and natural objects; apply problem solving skills to a situation.

Advanced
Students identify energy transformations; predict the effect of heat energy on water; diagram a complete electrical circuit; predict how simple machines affect the force needed to do work; describe the effects of weathering and erosion on Earth’s surface; describe relationships in weather data; explain how the Sun’s position and the length and position of shadows relate to the time of day; interpret and apply knowledge from a data table; identify appropriate steps, tools and metric units in an investigation; construct a graph and plot data; formulate a question for an investigation.

For this report, SEA websites were reviewed to determine the extent to which states are reporting, at the district level and to the public, the performance of students on statewide elementary school science assessments. It was found that all states report, for every district in the state, the percentage of students performing at each achievement level of the state's PLDs.

However, many states go beyond the requirements of NCLB and report scores at a district level, according to categories other than the achievement levels of the PLDs. It was found that 29 states create district level reports, such as Cluster Means Reports and District Results Reports that report average scores according to scientific discipline (Life Sciences, Physical Sciences, Earth/Space Sciences). The other 21 states and the District of Columbia may also provide similar reports, but no evidence of these reports could be found on SEA websites. It should be noted that only 13 of the 29 states that provide reports with sub-divided science discipline scores make these reports available to the public. For the other 16 states, subdivided scores at the district level are only available to school officials, typically through secure on-line portals.

c. Are student scores on geosciences assessments reported at the state level? What are they?

Much like the district level reporting, SEA websites were reviewed to determine the extent to which states provide to the public the performance of students on statewide elementary school science assessments at the state level. It was found that all states report, at the state level, the percentage of students performing at each achievement level of the state's PLDs.

In addition, some states go beyond the requirements of NCLB and report state-level performance according to categories other than the achievement levels of the PLDs. It was found that 26 states create state level reports, such as Cluster Means Reports and State Results Reports that report scores according to scientific discipline. Again, the other states may be reporting similar reports, but no evidence could be found of these reports on SEA websites. Additionally, only 14 of the 26 states make their reports available to the public.

d. Are student scores on geosciences assessments included in international comparisons? What are they?

The only assessment that measures elementary-level science achievement of U.S. students and compares them to those of students in other countries is the *Trends in International Mathematics and Science Study* (TIMSS). The Study is administered in the United States by the U.S. Department of Education's National Center for Education Statistics (NCES). The NCES is also responsible for representing the United States in international collaboration on TIMSS. The Study is coordinated internationally by the International Association for the Evaluation of Educational Achievement (IEA), based in Amsterdam.

TIMSS data were collected from students at Grade 4 in 1995, 2003, 2007 and 2011. The next assessment is scheduled for 2015. Assessment items are categorized according to content domain, main topic, and cognitive domain. The three main content domains are Life Science, Physical Science, and Earth Science.

12 states participated in the Grade 4 TIMSS assessments between 1995 and 2011: 6 in 1995; 1 in 2003; 2 in 2007; and 9 in 2011. 4 states participated in more than one assessment. More than 70 countries have participated in the Grade 4 TIMSS studies since 1995: 29 in 1995; 26 in 2003; 37 in 2007; and 50 in 2011.

For each assessment, state and country scores can be obtained that are subdivided by content domain (Life Science, Physical Science, and Earth Science).

Table 11: **State Participation in TIMSS**

State	1995	2003	2007	2011
Alabama				X
California				X
Colorado	X			X
Connecticut				X
Illinois	X			
Indiana		X		X
Florida				X
Massachusetts	X		X	X
Minnesota	X		X	X
Missouri	X			
North Carolina				X
Oregon	X			

e. How often are the monitoring programs (e.g., state assessments) administered?

As mentioned earlier, the No Child Left Behind (NCLB) Act required that states implement annual assessments in science. The Act stated that states should begin giving their assessments in the 2007-2008 school year. At the time of writing, all states are implementing statewide science assessments annually at the elementary level.

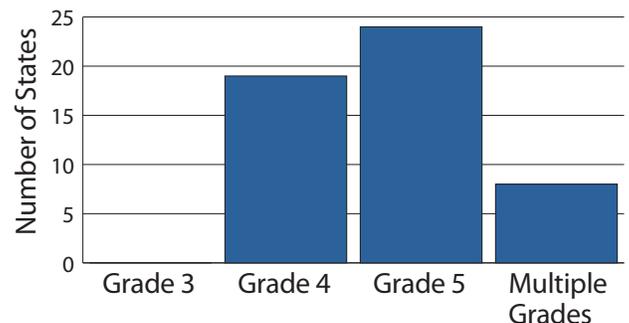
f. At what grade(s) are the monitoring programs administered?

As mentioned earlier, the No Child Left Behind (NCLB) Act required that states implement annual assessments in science not less than one time during Grades 3-5. At present, no states implement a statewide assessment solely at Grade 3. 19 states implement a single assessment at Grade 4, and 23 states and the District of Columbia administer a single assessment at Grade 5. 8 states implement science assessments at more than one elementary grade, as shown in the following table.

Table 12: **States that Implement Elementary Level State Science Assessment at More than One Grade**

State	Grade Levels
Alabama	3, 4, 5
Georgia	3, 4, 5
Iowa	1, 2, 3, 4, 5
Louisiana	3, 4, 5
South Carolina	4, 5
Tennessee	3, 4, 5
Utah	4, 5
West Virginia	3, 4, 5

Figure 17: **Grade Level Implementation of State Science Assessments**



g. To what extent can student outcomes in the geosciences be compared to student outcomes in other areas of science?

As stated in sub-question 6c., it was found that 26 states create state level reports, such as Cluster Means Reports and State Results Reports, which provide scores on the statewide elementary science assessment according to scientific discipline and allow for comparison. Again, only 14 of these states make their reports available to the public.

Findings: Accountability

7. In what specific ways do student outcomes related to geosciences education matter?

a. In student evaluation?

The No Child Left Behind (NCLB) Act requires states to produce individual student interpretive, descriptive, and diagnostic reports. These “Individual Student Reports” should provide information pertaining to a student’s achievement on academic assessments that are aligned to a state’s standards.¹⁰

For this report, score interpretation manuals, individual student report guides, technical manuals, and test interpretation manuals were reviewed from each state to determine the extent to which states are producing individual student reports and the content of these reports. It was found that 47 states and the District of Columbia create individual student reports that describe an individual student’s performance on the state’s science assessment. The remaining 3 states may be producing individual student reports, but the SEA websites for these states do not provide information about such reports.

All states that produce individual student reports provide them to the parents or guardians of students. In addition, the reports are provided to teachers or made available to them by their schools.

For all states, the individual student reports describe an individual student’s performance on the statewide elementary science assessment in terms of scale score and achievement level. For 41 states and the District of Columbia, results are further subdivided by science discipline (Physical Science, Life Science, and Earth/Space Science) or by disciplinary topics.

b. In teacher appraisal?

In recent years, in response to the Race to the Top federal grant program, states and school districts have been reforming their teacher evaluation systems. States vary in terms of the control they exert over teacher evaluation.

¹⁰ U.S. Department of Education. (2003). *No Child Left Behind, Standards and Assessments, Non-Regulatory Guidance*. Retrieved April 17, 2015 from <https://www2.ed.gov/policy/elsec/guid/saaguidance03.doc>

Some states require all districts to adopt a single evaluation system, while others recommend a system that LEAs may either adopt or use as a guide in the development of a local model. The majority of teacher evaluation systems that are being used at both the state and local levels evaluate teachers using multiple measures of performance. These may include classroom observations, student and parent surveys, lesson plan reviews, and teacher self-assessments. In addition, many states and districts include student achievement measures in teacher evaluation.

For this report, SEA websites were reviewed and SEA officials were asked the extent to which elementary level statewide assessments in science are being used in teacher evaluation systems. It was found that the elementary science assessment is not a component of teacher evaluation for 27 states (4 officials stated that it would be at some future point, as the teacher evaluation system is developed). However, for 18 states, the elementary science assessment may be used, in part, to evaluate teachers. For these states, the decision whether to use the science assessment for evaluation purposes is dependent on a number of factors. In some states, it is a local decision. In other states, the science assessment can be used only for teachers at the same grade level at which the assessment is implemented. In some states, the evaluator (e.g., principal, assistant principal) and the teacher work together in selecting the student achievement measures that will be used in the teacher’s evaluation, which may or may not include the statewide science assessment. For 6 states the data could not be collected.

c. In district accreditation?

Accreditation is a process of validation in which the services and operations of schools are evaluated to determine if certain standards are met. The criteria to which public schools must adhere are usually set by state governments, but may also be determined by regional accrediting agencies. The services and operations evaluated vary by state but may include school administration, curriculum, instruction, attendance and enrollment, student performance, personnel, support services, and facilities and equipment.

For this report, SEA officials were asked whether student outcomes in statewide science assessments at the elementary level are part of accreditation of public schools at the district level. 10 officials reported that science assessment data is used for accreditation purposes. 1 official stated that this data is not being used currently,

but will be at some future point. 5 officials reported that accreditation criteria are determined at the local level or by regional accreditation agencies and they would have to be contacted for more information. Officials from 15 states and the District of Columbia reported that statewide elementary level science assessments are not considered for accreditation purposes. For 19 states the data could not be collected.

d. In statewide monitoring?

In the United States, it is the responsibility of each state to ensure that every child has access to a quality education. As such, states develop policies, procedures, and provide assistance to ensure that their schools are educationally adequate. To meet this goal, each state needs to know the condition of their school systems, including such factors as facilities, curriculum, and educational outcomes.

For this report, state officials were asked the extent to which the results on statewide elementary science assessments are used in monitoring the adequacy of state educational systems. Officials from 24 states and the District of Columbia reported that they are used while 9 officials reported that they are not used. For 17 states the data could not be collected.

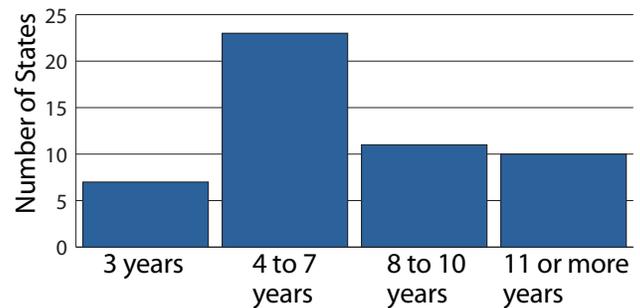
e. Are trends in student outcomes over time in geosciences learning reported in some way? What are they?

As mentioned in the Monitoring Systems section, the No Child Left Behind (NCLB) Act required that all states annually assess their students in science at least one time in Grades 3-5 beginning in the 2007-2008 school year. In addition, the Act requires states to report on student achievement. At the time of writing, states have been required to implement and report on their science assessments at the elementary level for eight years.

For this report, SEA websites were reviewed to determine the extent to which states provide to the public historical data on the performance of students on the statewide elementary science assessment. It was found that student achievement data could be accessed for statewide elementary science assessments implemented prior to the 2014-2015 school year for all states and the District of Columbia. 7 states provide achievement data for no more than the past 3 school years (2011-2012 to 2013-2014). 22 states and the District of Columbia provide achievement data for no more than between 4 and 7 of the past school years (2007-2008 to 2013-2014).

11 states provide data for no more than between 8 and 10 of the past school years (2004-2005 to 2013-2014). 10 states provide data for 11 or more years (before 2004-2005 school year).

Figure 18: Reporting of Historical Achievement Data for Elementary Science Assessments



For all states, the historical data for statewide elementary science assessments provided to the public is reported as the percentages of students performing at each achievement level of the Performance Level Descriptors (PLDs). However, 10 states go beyond the PLDs and subdivide student performance according to scientific discipline (Life Sciences, Physical Sciences, Earth/Space Sciences).

Summary

Teacher Preparation

All states require elementary teachers to have at least a bachelor's degree and to have completed a state-approved teacher preparation program that includes a combination of coursework and fieldwork. While this generally occurs in state-approved (and, in many cases, nationally accredited) tertiary-level teacher education programs, there are many alternative routes to certification (e.g., Teach for America). Generally, teachers are licensed in either Elementary Education or Early Childhood Education, with the specific requirements and titles of those credentials varying somewhat from state to state. Almost all states require candidates for the Elementary Education credential to pass a knowledge test in science that includes geoscience concepts. Most of the states require a similar test in science for the Early Childhood credential. In the majority of states, a teacher's license is valid for 5 years. Renewal for an additional 5 years occurs upon the completion of approved professional growth activities. For most states, professional development courses or programs in the geosciences can be applied towards recertification credit.

All states provide a set of elementary level science standards for school districts, schools, and teachers to use in the planning and development of science curricula, including the geosciences. For approximately 40% of states, the standards are the only guidelines provided by the state for curriculum development. The remaining states provide a variety of additional resources for the development of elementary science programs. Support items include science frameworks, curriculum maps, learning progressions, benchmark maps, curriculum development guides, model units, lesson plan templates, assessment guidelines, and on-line lesson plan portals.

In 65% of states, textbooks or other published educational programs are selected at the local level. The remaining states are textbook adoption states and choose at the state level a selection of textbooks from which districts can choose. For the most part, the elementary science textbooks offered by these states include titles that are specific to the geosciences.

Professional development (PD) of teachers comes in many forms and at various points throughout teachers' careers. In most states, PD is organized and provided by Local Education Agencies, a number of which are known to be offering geosciences-related programs. In approximately 30% of states, the State Education Agency is involved, in some way, in the delivery of geosciences-related professional development. The extent of this

involvement varies considerably from SEA grant supported institutions to websites that provide on-line geoscience-related courses. However, PD support at the state level is slightly higher (approximately 50%), when it is focused on the implementation of new standards, which, for elementary science, includes the geosciences.

Curriculum

All states provide curriculum standards that guide elementary teachers in determining what is to be taught in science. These standards are, in all cases, presented as statements that describe the knowledge and skills students should possess after instruction. In approximately 60% of states, standard statements occur on two levels, with overarching statements defined further by sub-standard statements. For 84% of states, the standards are grade-level specific, while for the remainder of states they are organized by grade-level bands or benchmark grade-levels. In all states, except one, the standards are subdivided into scientific disciplines: Physical Sciences, Life Sciences, and Earth and Space Sciences. Additionally, over 80% of states identify their Earth and Space Sciences standards by certain core ideas in the geosciences. The result is that, overall in the United States, clear targets are established for learning in the geosciences.

Within their science standards, approximately 85% of states include current issues in the geosciences. These can be described as Earth science processes altered by human activities or Earth science processes that threaten human well-being. Topics include energy resources, climate modification, waste disposal, mining resources, and natural hazards.

Approximately 29% of states include elementary science standards that emphasize career options/career exploration in the field of geosciences. For most of these states, teachers are to address these standards at the upper elementary levels (3-5).

All states periodically review their standards for quality and adherence to current research and academic advances. However, controversies and/or budget constraints may cause some state standards to remain in place, despite the schedule for revision. Approximately 50% of states maintain standards that were adopted or revised within the past 6 years. The standards for most of the remaining states were put in place between 7 and 10 years ago. However, the standards for 40% of states are either currently being reviewed or will undergo a review process within the next several years.

Instruction

The active investigation of science is promoted by states primarily through their standards. The elementary science standards for all states provide certain guidelines to teachers for science instruction, which includes that of the geosciences. Approximately 70% of state standards promote an “inquiry-based” approach to learning science. For the remaining states, which include those that have adopted the Next Generation Science Standards, an approach is promoted that includes all the elements of inquiry-based learning, but is coupled with engineering practices. No states suggest strategies that be used in place of an inquiry-based approach, however, a small portion of states (16%) suggest strategies for science instruction that can be used to facilitate inquiry.

The majority of states (71%) provide a rationale for an inquiry-based approach to learning elementary science. The most commonly shared justification suggests that an inquiry-based approach mimics the work of professional scientists and students learn best when they use methods and thinking processes that parallel the work and construction of knowledge by practicing scientists.

The work of scientists embraces a wide range of technologies, and major advancements in science are often accomplished through the use of sophisticated applications of technology. As a result, the role of technology in science education has become increasingly prevalent. Although important, decisions regarding the incorporation of technology in the elementary science classroom are not the purview of states and are typically left to schools and school districts. Consequently, it is not possible to accurately describe the extent to which teachers are integrating technology into their science curricula. This is further complicated by the fact that “technology” can refer to both the means by which instruction is delivered (i.e. instructional technology, such as interactive white boards), and the focus of instruction (e.g., the role of technology in scientific discovery). In the latter case, variations of what is included in “technology” (e.g., whether non-electronic devices are included), further complicate data collection.

Learning Contexts

The impact of class size remains a controversial topic in education. While the effect of class size in some subject areas may be open to debate, it is reasonable to assume that a teacher with more students would face different challenges when doing active learning strategies such as labs and other hands-on activities, which are commonly

used in geosciences instruction. For the majority of states, the regulation and monitoring of class size in elementary classrooms is a local issue. Some State Education Agencies collect classroom size data, and among those states, there is a wide variation in average class sizes as well as the maximum allowable number of students in any one class. This variation suggests uneven opportunities in some places versus others for the use of active learning strategies in the geosciences.

All state standards require teachers to spend time on science instruction, which includes the geosciences. However, for approximately 35% of states, the amount of time teachers should spend on science instruction is not defined. For another 45% of states, instructional time requirements are determined at the local level. Only 10% of states have a time requirement for science instruction at the elementary level.

Students receiving English as a Second Language (ESL) support and other students whose needs are addressed on an Individualized Education Plan (IEP) are eligible for specialized support and services designed to help them build essential skills and achieve educational goals and objectives. At times, these students are removed from classrooms to receive specialized instruction. When this occurs, students may miss instruction in certain academic areas, including science. For most states (over 75%), decisions regarding the best times during the school day to provide support mechanisms to English Language Learners and special education students are made at a local level. As a result, the impact of specialized services for these students on the learning of geosciences is difficult to determine.

Extra-Curricular Programs

Beyond the classroom, students receive an array of educational and recreational activities through afterschool and informal education programs. There is evidence that in most states programs are being offered that provide elementary students opportunities for geosciences study. While most states are able to provide some description of these programs, no data are systematically kept regarding their availability.

Additionally, in some states, students are provided remedial education services for subjects in which they lag far behind their counterparts in school performance. Remedial education may involve in-class adaptations or specialized instruction that occurs outside of the classroom. In 10% of states, remedial services are required for students in science. However, for the majority of states, decisions regarding remediation are made at the local level.

Monitoring Systems

All states implement annual tests in science as part of their statewide assessment system at the K-5 level, most commonly at Grade 5, but many at Grade 4. A few states (16%) conduct assessments in more than one grade (e.g., at Grades 4 and 5 or 3, 4, and 5). Only one state reported testing science at the K, 1, or 2 levels. Every state's elementary science assessment is aligned to a set of state science standards and measures achievement of those standards. However, a number of states have recently adopted new standards and are in the process of revising their science tests to bring them into line with the revised standards. 96% of states identify the ratio of their elementary assessments that is devoted to each scientific discipline area, namely, Physical Sciences, Life Sciences, and Earth/Space Sciences.

Each state reports student achievement on the elementary science assessment according to a set of Performance Level Descriptors (PLDs). These provide a student's general conceptual understanding of science content and the application of science processes. As such, the descriptors aggregate achievement of the science disciplines. Approximately 70% of states maintain PLDs according to four levels of achievement, while the remaining states maintain three or five levels. Each state reports to the public the percentage of students performing at each achievement level of the PLDs, at both the district and state levels.

In addition to describing achievement on the elementary science assessment according to the PLDs, many states report performance according to scientific discipline. More than half of states are known to create district and state level reports that provide average scores for the Physical Sciences, Life Sciences, and Earth/Space Sciences. However, many of these states do not make these reports available to the public and provide them only to school, district, and state officials. Consequently, this makes specific monitoring of geosciences learning challenging or impossible in many locations.

The Trends in International Mathematics and Science Study (TIMSS) is the only assessment that measures elementary-level science achievement of U.S. students for comparison to students in other countries. This assessment has been conducted four times over the past 20 years with 12 states participating one or more times in each of those tests. For each state, TIMSS reports the average score according to science discipline.

Accountability

At the individual level, more than 94% of states are known to create Individual Student Reports (ISRs) that describe the achievement of each student participating on a statewide science assessment. Most ISRs provide to parents or guardians, as well as teachers, a student's performance according to the achievement levels of a state's PLDS along with scores subdivided by scientific discipline.

Teacher evaluation systems are used in most states to measure the effectiveness of teachers in student learning. The majority of these systems use multiple measures to evaluate teachers, with evaluators and teachers often selecting the measures that will be used in the evaluations. In approximately 35% of states, science assessment data is known to be an optional measure in teacher evaluation. However, the selection of this measure is dependent on local conditions. As a result, the extent to which student performance on statewide elementary level science assessments is used to evaluate teachers is difficult to gauge.

A variety of criteria are used by different state and regional accrediting agencies to evaluate schools and school districts. The use of statewide elementary level science assessment data for district accreditation was difficult to determine. A little more than half of states provided descriptions of district accreditation processes. Of these states, some use assessment data for accreditation purposes, but most do not.

The use of elementary level science assessment data in monitoring the adequacy of state educational systems is also mixed. Approximately 50% of states provided descriptions of their monitoring systems with most stating that assessment data are used for monitoring purposes.

States have been implementing statewide science assessments at the elementary level for at least eight years. All states make available, to the public, data that describe the performance of students, over time, in elementary science. Most states provide less than 8 years of data, with no states providing less than 3 years. 40% of states provide assessment data for 8 or more years. In all cases, states report the percentage of students performing at each achievement level of the Performance Level Descriptors. Only 20% of states provide student performance data according to scientific discipline.

Sources of Information

State Education Agency Web Sites, last accessed April 17, 2015.

Alabama: <http://www.alsde.edu/>

Alaska: <http://www.education.alaska.gov/>

Arizona: <http://www.azed.gov/>

Arkansas: <http://www.arkansased.org/>

California: <http://www.cde.ca.gov/>

Colorado: <http://www.cde.state.co.us/>

Connecticut: <http://www.sde.ct.gov/>

Delaware: <http://www.doe.k12.de.us/>

District of Columbia: <http://dcps.dc.gov/>

Florida: <http://www.fldoe.org/>

Georgia: <http://www.gadoe.org/>

Hawaii: <http://www.hawaiipublicschools.org/>

Idaho: <http://www.sde.idaho.gov/>

Illinois: <http://www.isbe.state.il.us/>

Indiana: <http://www.doe.in.gov/>

Iowa: <http://www.educateiowa.gov/>

Kansas: <http://www.ksde.org/>

Kentucky: <http://www.education.ky.gov/>

Louisiana: <http://www.louisianabelieves.com/>

Maine: <http://www.maine.gov/doe/>

Maryland: <http://www.marylandpublicschools.org/>

Massachusetts: <http://www.doe.mass.edu/>

Michigan: <http://www.michigan.gov/mde>

Minnesota: <http://www.education.state.mn.us/>

Mississippi: <http://www.mde.k12.ms.us/>

Missouri: <http://www.dese.mo.gov/>

Montana: <http://www.opi.mt.gov/>

Nebraska: <http://www.education.ne.gov/>

Nevada: <http://www.doe.nv.gov/>

New Hampshire: <http://www.education.nh.gov/>

New Jersey: <http://www.state.nj.us/education/>

New Mexico: <http://www.ped.state.nm.us/>

New York: <http://www.nysed.gov/>

North Carolina: <http://www.ncpublicschools.org/>

North Dakota: <http://www.dpi.state.nd.us/>

Ohio: <http://www.education.ohio.gov/>

Oklahoma: <http://www.ok.gov/sde/>

Oregon: <http://www.ode.state.or.us/>

Pennsylvania: <http://www.education.pa.gov/>

Rhode Island: <http://www.ride.ri.gov/>

South Carolina: <http://www.ed.sc.gov/>

South Dakota: <http://www.doe.sd.gov/>

Tennessee: <http://www.tn.gov/education/>

Texas: <http://www.tea.state.tx.us/>

Utah: <http://www.schools.utah.gov/>

Vermont: <http://www.education.vermont.gov/>

Virginia: <http://www.doe.virginia.gov/>

Washington: <http://www.k12.wa.us/>

West Virginia: <https://wvde.state.wv.us/>

Wisconsin: <http://www.dpi.wi.gov/>

Wyoming: <http://www.edu.wyoming.gov/>



Credit: United States Army Corps of Engineers



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