ARKANSAS
K-12 SCIENCE STANDARDS
EDUCATION FOR A NEW GENERATION

Review of the
Next Generation Science Standards

A Summary of the Work by Arkansas Educators

through April, 2014

ARKANSAS DEPARTMENT OF EDUCATION
LEADERSHIP SUPPORT SERVICE

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Executive Summary

The Arkansas Next Generation Science Standards Review Committee recommends the adoption of the April 2013 release of the Next Generation Science Standards (NGSS) as the Arkansas K–12 Science Standards. The NGSS differ from our current state science standards in several ways. The NGSS are

- research–based and internationally benchmarked;
- three–dimensional, written as performance expectations that build science concepts coherently across K–12;
- focused on a smaller set of disciplinary core ideas, integrating engineering into science education;
- rigorous, having the potential to raise the level of scientific inquiry in science classroom instruction at all levels by emphasizing the core ideas of engineering design and technology applications; and
- focused on preparing students for college and careers. (NGSS Lead States, 2013)

This report summarizes the contributions of the Arkansas Department of Education (ADE) that led to the final version of the NGSS, the information that became the foundation of the review committee's recommendation, the committee's responses based on their vision for K–12 science education in Arkansas, and a tentative NGSS implementation plan.

The recommendation in this report is the result of the committee's work while engaged in three adoption tasks: (1) Articulate the Vision for Science Education in Arkansas, (2) Implications of NGSS Shifts for Educators and Students, and (3) NGSS Conceptual Shifts. These tasks focused the work on six conceptual shifts identified by the NGSS authors for consideration by state review teams. The six conceptual shifts are as follows:

- K–12 science education should reflect the interconnected nature of science as it is practiced and experienced in the real world.
- The NGSS are student performance expectations — NOT curriculum.
- The science concepts in the NGSS build coherently from Kindergarten through Grade 12.
- The NGSS focus on deeper understanding of content as well as application of content.
- Science and engineering are integrated in science education from Kindergarten through Grade 12.
- The NGSS make explicit connections to the CCSS. (NGSS Lead States, 2013)

The Arkansas NGSS Review Committee considered the effect of these shifts on science education in the state. Following this thoughtful discussion, 88 percent of responding members agreed that the NGSS are essential to the success of science education in Arkansas, and 100 percent agreed that NGSS supports Arkansas's Science, Technology, Engineering, and Mathematics (STEM) initiative.

The implementation of new science content standards will come with both opportunities and challenges. The recommendation of Dr. Tracy Tucker and the Curriculum and Assessment science specialists at ADE is that the target for implementation of Arkansas K-12 Science Standards will be August, 2016 in Grades K–4, August 2017 in Grades 5–8, and August 2018 in Grades 9–12. States are advised not to implement new science standards too quickly after adoption. States are encouraged to take the time to foster the success of the Common Core State Standards (CCSS) before implementing new standards (NGSS Lead States, 2013).

Respectfully submitted on behalf of the Arkansas NGSS Review Committee and Dr. Tracy Tucker, Director of Curriculum and Instruction, Arkansas Department of Education

Section I: Leading up to the NGSS

Why Grades K–12 Science Standards Matter

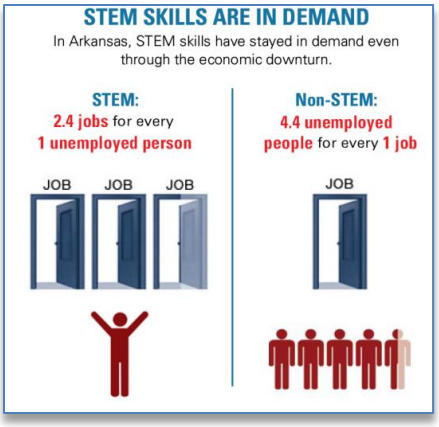
Science—and therefore science education—is central to the lives of all Americans, preparing them to be informed citizens and knowledgeable consumers (NGSS Lead States, 2013). The NGSS Review Committee determined that Grades K–12 science standards matter for four significant reasons.

First, science standards matter because the 2005 Arkansas science standards are based on the *National Science Education Standards* (NRC, 1996), which are now seventeen years old. Major advances have since taken place in the world of science and in the understanding of how students learn science. In response to that need, the National Research Council (NRC) formed a committee to develop *A Framework for K–12 Science Education* (NRC, 2012). This was a critical first step in the development of the NGSS because it served as the blueprint for a more rigorous, robust set of science standards.

Second, science standards matter because the role of science in college and career readiness is changing dramatically and new standards must stand ready to meet that change. Governor Mike Beebe (2011) stated the following:

> By 2020, three–fourths of the jobs available in Arkansas will require advanced skills in science, technology, engineering or mathematics. Job seekers who lack training in these STEM disciplines will be forced to compete for a dwindling pool of low–wage jobs. If today's students are going to meet the needs of tomorrow's industries, we must increase their performance in these critical subjects.

The goal of STEM Works, an initiative of the Governor's Workforce Cabinet, is to transform education by recognizing that future demands will be driven by the 21st century economy. A major component of this initiative is to improve secondary school STEM education through support for New Tech high schools, Project Lead the Way, and EAST. The number of students reached through these programs has increased steadily since 2011 (AR Works, 2013). As part of their work, the NGSS Review Committee studied STEM data specific to Arkansas provided by Change the Equation, a nonprofit organization working to improve the quality of STEM learning in the United States (Appendix A).



Source: Change the Equation, 2013

Third, science standards matter because Arkansas has already shown a strong commitment to rigor through its adoption of the CCSS and its position as a governing state in the Partnership for Assessment of Readiness for College and Careers (PARCC). The next logical step is to move toward college and career ready science standards.

Fourth, science standards matter because Arkansas's students are performing below average on national and state science assessments (Appendix B). For example, Arkansas students scored below the national average on math and science assessments administered by the National Assessment of Educational Progress (NAEP).

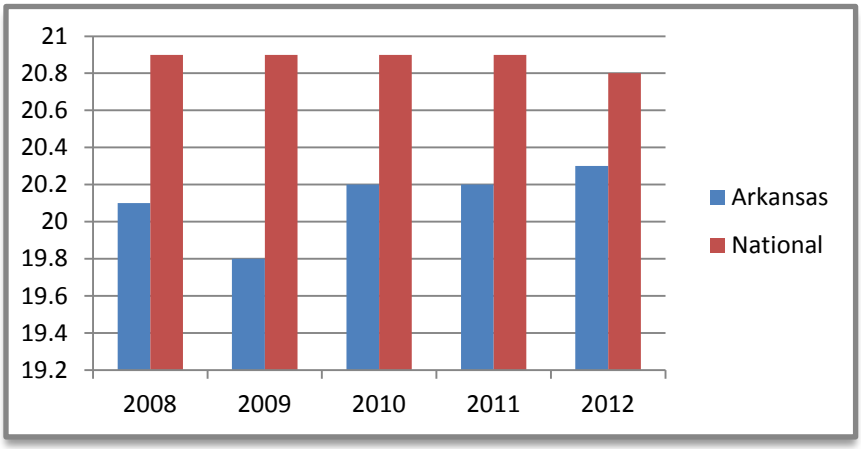
2009 NAEP: Percentage of Students at or Above Proficient

	Arkansas	U.S.	Top 3 States
4th grade math	36%	38%	56% (MA, MN, NH)
8th grade math	27%	33%	48% (MA, MN, NJ)
12th grade math	16%	25%	33% (MA, NH, NJ)†
4th grade science	29%	32%	46% (MA, NH, VA)
8th grade science	24%	29%	42% (MA, MT, ND)

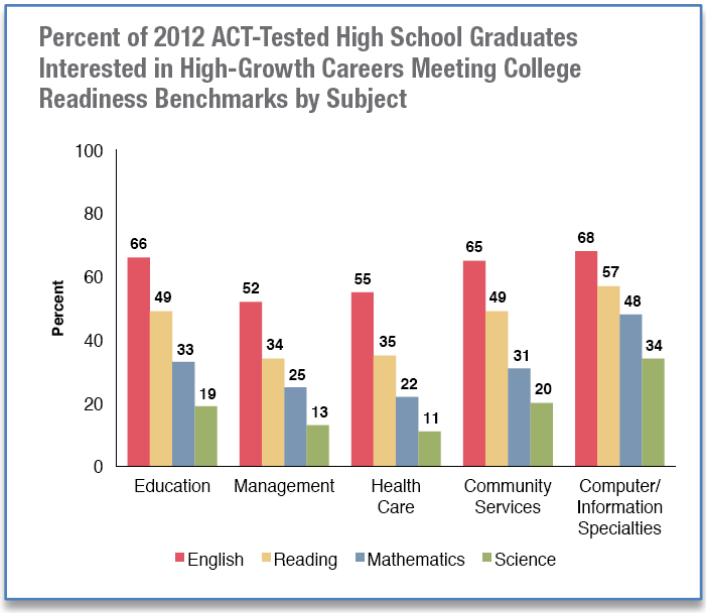
Source: NAEP, 2009.

ACT defines college and career readiness as the acquisition of the knowledge and skills a student needs to enroll and succeed in credit–bearing first–year courses at a postsecondary institution without the need for remediation. According to ACT, lack of students' college and career readiness in science may be a major factor in keeping high school graduates from successfully pursuing these high–growth career fields (ACT, 2012). As the graphic below indicates, the vast majority of Arkansas students are unprepared to be successful in a college–level biology course.

Five Year Trends—Average ACT Scores
Science



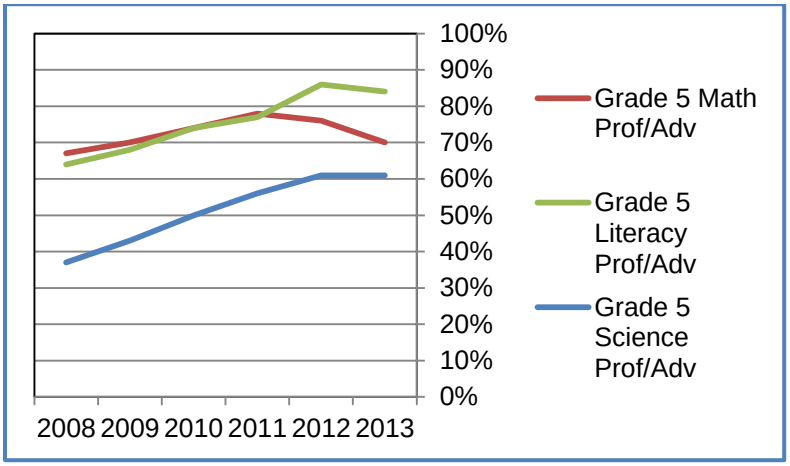
Source: ACT, 2012



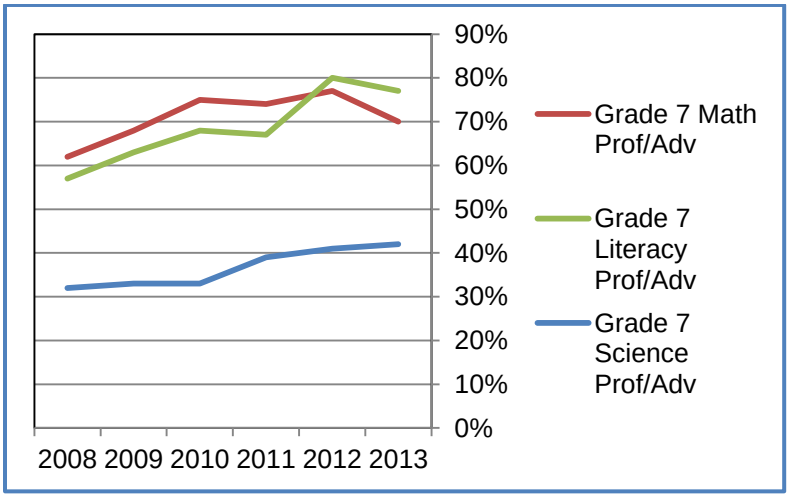
Source: ACT, 2012

Arkansas criterion–referenced science assessment scores in Grades 5 and 7 and end–of–course Biology have increased over time but continue to be well–below proficiency levels in English and mathematics. The six–year score trends are shown below.

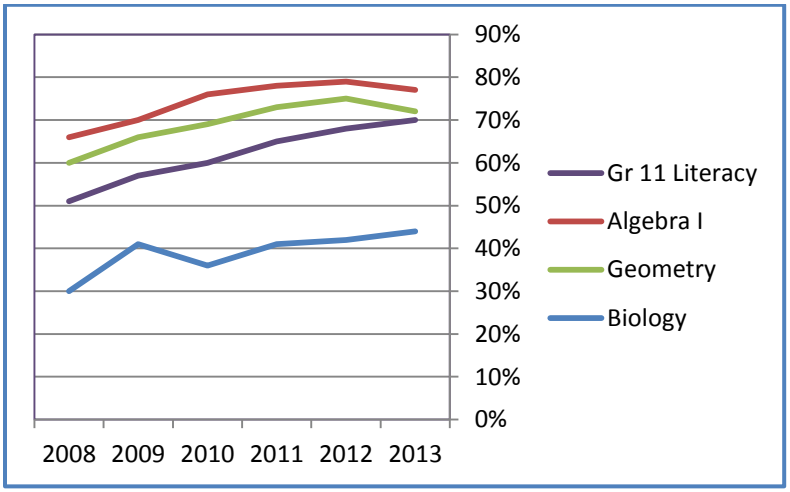
Grade 5
Percentage of Students Scoring Proficient or Advanced on Arkansas Augmented Benchmark Assessments



Grade 7
Percentage of Students Scoring Proficient or Advanced on Arkansas Augmented Benchmark Assessments



High School Exams
Percentage of Students Scoring Proficient or Advanced



Source: ADE, 2013

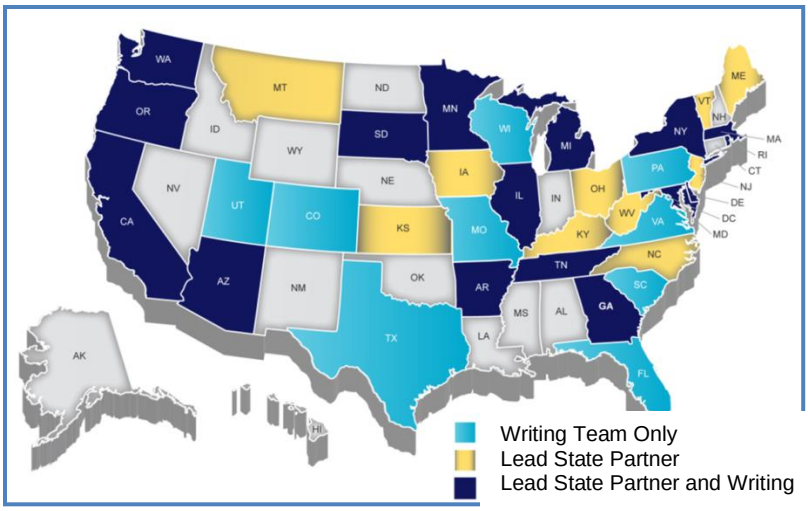
NGSS Development

The NRC, the National Science Teachers Association, the American Association for the Advancement of Science, and Achieve completed a two–step process to develop the NGSS. *A Framework for K–12 Science Education* was the critical first step because it is grounded in the most current research on science and science learning and identified the science that all K–12 students should know. To undertake this effort, the NRC convened a committee of 18 individuals who are nationally and internationally known in their respective fields. The committee included practicing scientists, including two Nobel laureates, cognitive scientists, science education researchers, and science education standards and policy experts. In addition, the NRC used four design teams to develop the document. These four design teams, in physical science, life science, earth/space science and engineering, developed the sections for their respective disciplinary area. (NGSS Lead States, 2013)

The second step involved the writing, review, and revision of the NGSS in a state-led process. A writing team was comprised of 41 members and included experts in elementary, middle, and high school science, students with disabilities, English language acquisition, state–level standards and assessment, and workforce development. K-12 educators played a central role in the development and made up most of the writing team. Arkansas was represented well on the writing team by two middle school teachers, Kathy Prophet and Melissa Miller. States interested in being part of the development process were identified, and Arkansas committed to acting as one of the 26 lead states. As part of our lead state agreement (Appendix C), signed by Dr. Tom Kimbrell and State Board Chair Ben Mays in October 2011, Arkansas agreed to

- strongly consider the adoption of the NGSS*;*
- identify a state science lead;
- participate in multi–state action committee meetings;
- publicly announce state participation;
- form a broad–based committee to provide input on drafts of the standards;
- publicly identify an adoption timeline; and
- work with other states to develop implementation and transition plans. (Appendix D)

State-led NGSS Development Process



Source: NGSS Lead States, 2013

To meet our commitment as a lead state, Michele Snyder, ADE Science Curriculum Specialist, was identified as the state science lead and attended meetings with the NGSS writers and lead state partners during the development process. Arkansas has been working with several multi–state action committees: Council of Chief State School Officers–Science State Collaborative on Assessment and Student Standards, Building Capacity for State Science Education, Council of State Science Supervisors, a College and Career Readiness Team, and the Achieve NGSS Institute. The opportunity to continue this collaboration is ongoing as states move from adoption to implementation. For example, adopting states become members of the NGSS Network to support one another in sustaining a successful implementation.

Another step in meeting our commitment as a lead state was the development of the Arkansas Broad–based Stakeholder Committee, which provided input throughout the writing and revision process. The 39–member committee was composed of K–12 educators, STEM business and industry leaders, career and technical educators, informal science educators, higher education representatives, and Arkansas State Board of Education members (Appendix E). These stakeholders critiqued for Arkansas and the other lead states five successive drafts of the standards. The committee members gave special attention to their area of expertise and evaluated the rigor, coherence, and cohesiveness of the draft standards. Michele Snyder traveled to D.C. to discuss feedback of all the states directly with the writers. The states made recommendations that directed the writers in the direction needed to solve particular issues. This close attention to detail ensures that the standards will effectively serve as the basis for developing STEM curriculum that will make our students college and career ready in science.

Also as part of our lead state agreement, ADE publicly announced its role in the NGSS development and adoption timeline in multiple ways. Since summer of 2011, science specialists representing ADE, education service cooperatives, and STEM Centers have

worked together to offer one or two–day professional development workshops titled Planning for New Science Standards (Appendix F). This workshop introduced educators from around the state to *A Framework for K–12 Science Education* (NRC, 2012). Dr. Tracy Tucker has continued to keep stakeholders informed by sending messages through the ADE–CCSS listserv and posting to Science Standards Frequently Asked Questions (Appendix G) on the ADE website.

NGSS Structure

As recommended by *A Framework for K–12 Science Education*, the NGSS are organized around three dimensions: science and engineering practices, crosscutting concepts, and disciplinary core ideas. Each standard is composed of performance expectations, which are the assessable statements of what students should know and be able to do. Below is a generalized graphic of a standard. The color coded boxes (foundation boxes) include descriptions of the three dimensions that were used to construct the set of performance expectations for each standard. The descriptions are hyperlinked back to *A Framework for K–12 Science Education*. The last section (connection box) is designed to show to how the performance expectations in each standard connect to other performance expectations. This section hyperlinks those connections to the aligned CCSS and to other NGSS standards vertically and horizontally across Grades K–12.

NGSS Standard

Performance Expectations		
Science and Engineering Practices Science and engineering practices are critical to scientific inquiry in any content area. These are not teaching strategies; they are a necessary student outcome to show proficiency in science.	**Disciplinary Core Ideas** Disciplinary core ideas are acquired by students through an overall K–12 learning progression and are taught at increasing levels of depth and complexity over time.	**Crosscutting Concepts** Crosscutting concepts provide the connective tissue between sciences. These concepts are found throughout all scientific disciplines and will be continually revisited and built on through the exploration of disciplinary core ideas.
Connections to • **Other science disciplines at this grade level** • **Other disciplinary core ideas for older and younger students** • ***CCSS in Mathematics and Language Arts***		

Source: NGSS Lead States, 2013

Arkansas educators had a voice in determining the structure of the NGSS by participating in the review of five different drafts. As a result, a user–friendly, interactive version of the NGSS is now available online (www.nexgenscience.org). In addition to the hyperlink features mentioned, this online version has pop–up descriptions of the science and engineering practices, the crosscutting concepts, and the disciplinary core ideas in the performance expectations and it also allows users to search the standards and organize content by both disciplinary core idea and by topic.

NGSS Content

NGSS are rich in content and practice and arranged in a coherent manner across disciplines and grades to provide all students an internationally benchmarked science education. The content is divided into four domains: Physical Science, Earth and Space Science, Life Science, and Engineering Design. The content is organized into grade levels at Grades K–5 and into grade–bands for Grades 6–8 and Grades 9–12. The writers have emphasized that the NGSS are not curriculum, but are expectations for what all students should know and be able to do in science and engineering; therefore, NGSS do not limit instruction.

The advancements of NGSS are the following:

- Every standard has three dimensions: Disciplinary core ideas (content), science and engineering practices, and crosscutting concepts. The integration of rigorous content and application reflects the real world practice of science and engineering.
- Science and engineering practices and crosscutting concepts are designed to be taught in context – not in a vacuum. The NGSS encourage integration with multiple core concepts throughout each year.
- Science concepts build coherently across K–12. The emphasis of the NGSS is a focused and coherent progression of knowledge from grade band to grade band, allowing for a dynamic process of building knowledge throughout a student's entire K–12 science education.
- The standards focus on a smaller set of content that students should know by the time they graduate from high school, focusing on deeper understanding and application.
- Engineering is integrated into science education by raising engineering design to the same level as scientific inquiry in science classroom instruction at all levels and by emphasizing the core ideas of engineering design and technology applications.
- The content is focused on preparing students for college and careers. The NGSS are aligned by grade–level and cognitive demand with the CCSS for English Language Arts and mathematics. This allows an opportunity for science to be a part of a child's comprehensive education, and it ensures an aligned sequence of learning in all content areas. The three sets of standards overlap and reinforce each other in meaningful and substantive ways. (NGSS Lead States, 2013)

NGSS content and usability are strengthened by the addition of several supporting documents, multiple appendices, and videos. Supporting documents include information on how to read the standards, public support statements, and summaries of the appendices. The appendices were the result of state feedback on what was needed to support the standards and include specific details, explanations, and research pertinent to users. For example, there is an appendix that explains the six conceptual shifts and another presents a series of research–based case studies on diverse student sub–populations. Additional appendices address aspects of the nature of science, the engineering design cycle, and the role of science, technology, and the environment. Curriculum development and grade–level alignment tools are available. Short informational videos are also posted. Refer to the NGSS website (www.nextgenscience.org) for more details.

Section II: Reviewing the NGSS

Responses to the NGSS Public Drafts

Overall, the feedback received on both public drafts of the NGSS was very positive. Almost all reviewers indicated that they liked the pedagogical vision, the integration of the three dimensions in the NGSS, and the structure of the NGSS itself. Most reviewers scored the performance expectations highly, but some also critiqued specific issues and offered suggested improvements (NGSS Lead States, 2013).

The following themes emerged from the comments submitted during the public comment period (May 11, 2012, to June 1, 2012) on how to improve the first public draft. Those issues included the following:

- concern that there was too much material
- suggestions for additional topics
- lack of language clarity
- concern about how engineering and technology were included and addressed
- confusion about the selection of one science and engineering practice over another in each performance expectation
- lack of guidance for incorporating crosscutting concepts
- lack of specificity in connections to other standards and other subjects
- concern about the organization of the standards
- concern about the amount of support needed for implementation of the standards (NGSS Lead States, 2013)

Arkansas was the 21st most active state (2,932 visits) on the NGSS website (Appendix H) when the first public draft was available for public comment. Based on that feedback, the following changes were made between the first and second public drafts:

- Ninety-five percent of the performance expectations were rewritten based on feedback, using more specific and consistent language.
- Selected content was removed after a college and career readiness review.
- Selected content shifted grade levels in the elementary standards.
- Engineering was integrated into the traditional science disciplines.
- More math expectations were added to the performance expectations.
- Course models were drafted for middle and high school.
- Nature of science concepts were highlighted throughout the document.
- The matrix delineating science and engineering practices was revised.
- A new chapter was added to describe the intent and use of crosscutting concepts.
- A new chapter on equity in implementation of the NGSS with diverse student groups was drafted.
- A glossary of terms was added.

- More flexibility in viewing the standards was provided by arranging the performance expectations according to both topic and disciplinary core idea.
- Additional flexibility was added to the website, allowing users to turn off pop–up description boxes. (NGSS Lead States, 2013)

The following themes emerged from the comments submitted during the second and final public comment period (January 8, 2013, to January 29, 2013) on how to improve the second public draft. The feedback indicated that changes had completely addressed some issues, and the percentage of reviewers concerned about the remaining issues was greatly reduced. Those remaining issues included the following:

- concern that there was still too much material
- suggestions for a few additional topics
- lack of language clarity
- concern about including and addressing engineering and technology
- confusion about the selection of one science and engineering practice over another in each performance expectation
- concern about the amount of support needed for implementation of the standards
- confusion about the coding and naming of performance expectations (NGSS Lead States, 2013)

Arkansas was the twelfth most active state (4,383 visits) on the NGSS website during the public comment period for the second and final public draft (Appendix I). The numbers of Arkansas visitors to the website increased partially due to the NGSS final draft review sessions hosted by the education service cooperatives and STEM centers. Based on the feedback, the following changes were made between the second public draft and the final release of the NGSS:

- Seventy-five percent of the performance expectations were edited to increase clarity, consistency, and specific feedback.
- A review of the central focus of each disciplinary core idea from *A Framework for K-12 Science Education* resulted in the removal of about 33 percent of the performance expectations and associated disciplinary core ideas while retaining the progression across the grade bands.
- Separate engineering design performance expectations (ETS1) were added to each grade band to supplement performance expectations that had integrated engineering design into the traditional science disciplines.
- Storylines, a description of the context and rationale for the performance expectations using essential questions, were added to the beginning of each grade band and section.
- The NGSS Appendix D: All Standards, All Students was expanded to include several vignettes. (NGSS Lead States, 2013)

NGSS Final Version Review Process

The Arkansas NGSS Review Committee reviewed the final version of the NGSS. The 44-member committee was a diverse group of K–20 educators from all five ACTAAP regions. The committee met June18–21, 2013, to review current research on science education including *A Framework for K–12 Science Education* (NRC, 2012) and the *Next Generation Science Standards* (NGSS Lead States, 2013). The goal was to prepare a report to inform the possible adoption of the NGSS as Arkansas's Grades K–12 science content standards.

The committee was surveyed for background knowledge. Forty–three members said they were aware of *A Framework for K–12 Science Education*. Twenty–seven members said they had given or received professional development on *A Framework for K–12 Science Education*. Thirteen members said they had viewed or submitted comments to the survey of the NGSS first public draft. Twelve members said they had viewed or submitted comments to the survey of the NGSS final public draft.

The committee divided into grade band subcommittees (Grades K–2, Grades 3–5, Grades 6–8, and Grades 9–12), reviewed each standard within each grade band, and came to consensus on a series of questions about the standards. The questions focused on key criteria of the standards, which included the following:

- clarity and specificity
- integration of the performance expectations
- learning progressions within each grade band
- the achievability and preparedness of students
- instructional implications
- science and engineering practices
- crosscutting concepts
- engineering design concepts
- connections to other standards within each grade band, across grade bands, and to the CCSS for ELA/Literacy and Math
- utility

The Grades K–2, Grades 3–5, and Grades 9–12 subcommittees divided up into small content groups (life science, earth science, physical science, and engineering) to evaluate the standards. The Grades 6–8 subcommittee reviewed the standards as a whole group and did not subdivide into content groups. In whole groups, the teachers discussed each standard and came to a consensus according to ten criteria. Refer to Appendix J for the committees' detailed review of the NGSS by grade band.

Results from the NGSS Adoption Tasks

Adoption Tasks 1, 2, and 3 were adapted for the review committee from three adoption tasks similarly titled in the *Next Generation Science Standards Adoption and Implementation Workbook* (Achieve & U.S. Education Delivery Institute (EDI), 2012).

Results of Adoption Task 1: Articulate the Vision for Science Education in Arkansas

Adoption Task 1 asked members five key questions to help them develop the vision for science education in our state. This vision is the cornerstone of the case for recommending adoption of the NGSS in Arkansas. A summary of the collective responses follows each of the five key adoption questions. Refer to Appendix L for more detailed summaries of the responses by grade band.

1. Are the NGSS essential to our success? Why or why not?

Forty participants responded of which 88 percent answered 'Yes' and 12 percent answered 'No' or I don't know' to this question.

A majority of the members recommended Arkansas replace the current set of science content standards with the NGSS. The Grades K–2 subcommittee agreed the Grades K–2 NGSS are essential to Arkansas science education because the standards are based on the cognitive levels of students, provide a progression of learning throughout Grades K–12, and incorporate a more realistic view of the work of scientists and engineers through a focus on science and engineering practices. The Grades 3–5 subcommittee agreed the NGSS are essential after looking at Arkansas NAEP scores and seeing how few Arkansas graduates are going into STEM fields. The middle school subcommittee acknowledged there are probably other options but affirmed that adopting the NGSS would be a step towards the vision. The NGSS not only raise the bar intellectually for students, but also challenge them to be critical thinkers, problem solvers, and skilled debaters, making them better global citizens. According to the Grades 9–12 subcommittee, the NGSS are important to improving current standards and academic expectations because the NGSS increase rigor and address current inadequacies in college, career, and STEM readiness in Arkansas.

A few high school subcommittee members thought the NGSS are not necessarily essential to the success of science education in Arkansas. These few considered the *Arkansas Science Curriculum Frameworks* to be perfectly fine. However, they did agree that if the Arkansas science content standards are revised, aspects of engineering and technology would need to be incorporated.

2. Will the NGSS fit into the overall STEM agenda for our state? Explain your answer.

Thirty–seven participants responded and 100 percent answered 'Yes' to this question.

Overwhelmingly, all of the responding members agreed the NGSS fit very well with the STEM agenda in Arkansas and that the NGSS would actually enhance and build the STEM initiative. Several commented that if NGSS are adopted, science, engineering and technology education could possibly be placed on an even playing field with literacy and mathematics education.

3. What are we trying to accomplish for our students? Why is this important?

Forty–four participants responded to this question.

Overall, the members who responded to this question agreed the goal of science education is to create scientifically literate citizens. The Grades K–2 subcommittee agreed that the goal of early childhood science education is to cultivate an early interest in science. They noted that research shows that an early interest in science is a major indicator of students who will eventually enter STEM–related careers. The Grades 3–5 subcommittee agreed that the goal at this level is to provide students with the tools to locate, evaluate, and use scientific and engineering information and skills to effectively make personal and community decisions. The Grades 6–8 members articulated that the goals at the middle school level are to develop student skills for defining and solving problems, working as individuals within a collaborative group, communicating information, and logically designing solutions to problems. The high school Grades 9–12 subcommittee agreed that the goal at the high school level is to provide students with opportunities to learn and do science that foster interest and motivate students to pursue careers in science and engineering. Graduating well–rounded students adept at problem solving and critical thinking is increasingly important in a world that emphasizes technology and engineering.

4. How will we know the vision has been achieved?

Forty participants responded to this question.

Responding members identified several factors that could indicate the vision for science education in Arkansas has been achieved. In the short term, the Grades K-2 subcommittee agreed that when the quality and quantity of science instruction in the elementary grades improve, Arkansas will be on the way to achieving the vision. In the long term, it will be evident that the vision has been achieved when the number of students enrolled in upper level science classes such as advanced placement courses increases, the number of students who pursue STEM–related degrees or certificates after high school graduation increases, and the number of graduates securing STEM–related jobs increases. The Grades 3–5 members agreed that the vision will be

achieved when students begin to think more critically about the world. The Grades 6–8 middle school members said it will be evident that the vision has been achieved when students emerge from high school with the skills necessary to go into the work force or continue in higher education with little or no remediation. The Grades 9–12 subcommittee identified national and local indicators. Nationally, NAEP scores should rise. At the state– level, ACT scores in science should rise. As a result, there should be a significant rise in the number of students from Arkansas entering STEM fields in college and/or career.

5. Describe what is keeping us from achieving the vision.

Thirty–seven participants responded to this question.

Responding members found many things keeping elementary science education in Arkansas from reaching the vision. According to the Grades K-5 teachers, the lack of accountability in science is keeping the vision from being met. Arkansas elementary teachers are not being held accountable by school administrators to provide an adequate amount of the time to science instruction in elementary grades. In addition, the fact that many elementary teachers lack content knowledge and science inquiry skills needed to teach science is keeping Arkansas from achieving the vision. Taking one or two science classes in college is not adequate for understanding the complex science concepts students in elementary are required to know. In addition, teachers teach the way they are taught. If elementary students are to be engaged in hands–on, higher–order thinking and learning experiences more often, college instruction needs to model this.

There are a number of items that are keeping the vision from being achieved at the middle and high school levels. A lack of funding is a major factor. Few schools have the resources to supply the needed instructional materials and to hire effectively trained science educators. Lack of communication is another big issue. For example, information about changes in curriculum and content standards is either misinterpreted or it is not passed on from administrators to teachers. Finally, the narrow focus of testing only literacy and mathematics prevents the vision for science education from being achieved.

Results of Adoption Task 2: Implications of NGSS Shifts for Educators and Students

Adoption Task 2 asked participants to consider a series of questions associated with each NGSS conceptual shift. This task was designed to facilitate respondents' understanding of the difference between our current science content standards and the NGSS and the six conceptual shifts demanded for faithful implementation. Refer to Appendix M for the list of questions that guided the committee members in considering the implications of the NGSS shifts for educators and students in Arkansas.

Results of Adoption Task 3: NGSS Conceptual Shifts

Adoption Task 3 asked participants to submit responses to a series of questions after contemplating implications of the NGSS shifts for educators and students in Arkansas.

Each of the six shifts was evaluated based on how difficult that shift will be to accomplish across our state. The difficulty level is based on the following scale: 1…..……2…….…3……..…4……..……5.

Easy Moderate Difficult

Perceived Level of Difficulty of the NGSS Conceptual Shifts

NGSS Conceptual Shifts	Perceived Level of Difficulty
K–12 science education should reflect the interconnected nature of science as it is practiced and experienced in the real world.	59% determined this to be a moderately difficult shift
The NGSS are student performance expectations–NOT curriculum.	74% determined this to be a moderately difficult shift
The science concepts in the NGSS build coherently from K–12.	55% determined this to be a difficult shift
The NGSS focus on deeper understanding of content as well as application of content.	78% determined this to be a moderately difficult shift
Science and engineering are integrated in the NGSS, from K–12.	76% determined this to be a difficult shift
The NGSS and CCSS (English Language Arts and Mathematics) are aligned.	48% determined this to be an easy shift

Refer to Appendix N for a summary by grade band of the perceptions of the respondents on the degree of the difficulty of accomplishing each of these shifts in Arkansas.

Section III: Transitioning to the NGSS

Historically, the revision and implementation of new content standards has come with challenges and opportunities. Arkansas is facing many of those challenges with the implementation of the CCSS. The CCSS initiative is requiring a combined effort from stakeholders at all levels, but the result has been an opportunity for cooperation and collaboration at a level not previously experienced in the state. The endorsement of the NGSS will align with and can invigorate that initiative. The lessons learned and systems created during the CCSS implementation will inform and support the changes needed to improve science curriculum and instruction in Arkansas.

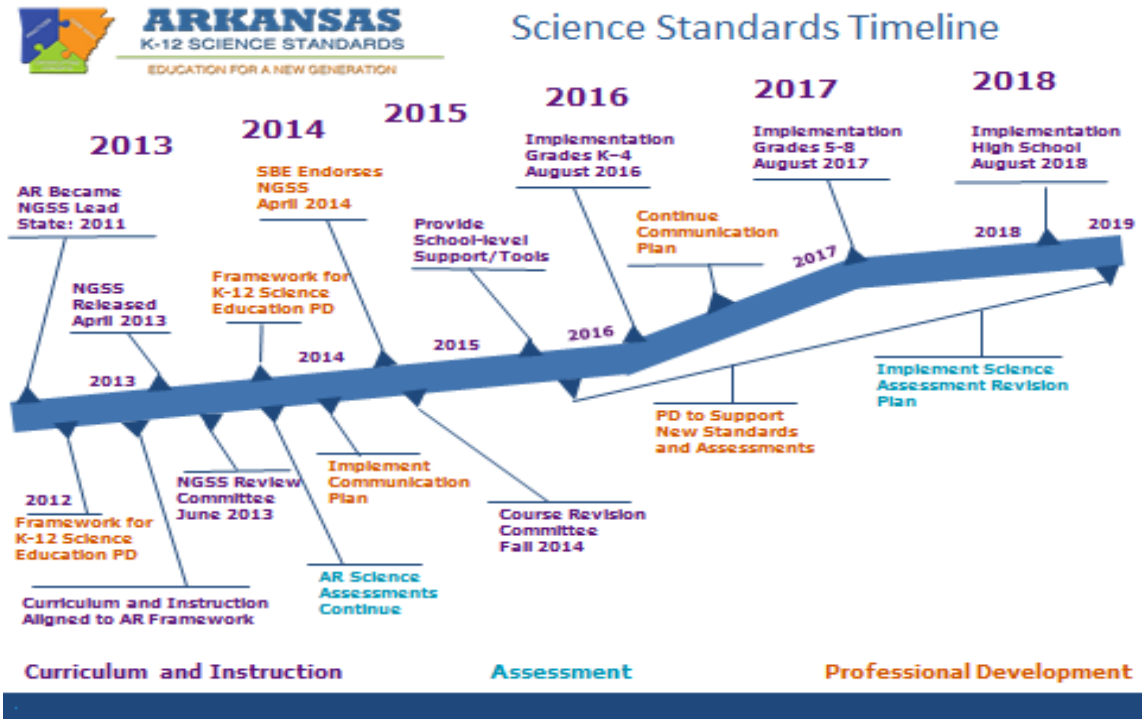
Twelve states have adopted the NGSS to date: California, Kansas, Kentucky, Maryland, Rhode Island, Vermont, Delaware, Washington, Illinois, Nevada, Oregon, and the District of Columbia. Tentative implementation timelines of some the adopting states are summarized as follows:

- California initially plans to implement during the 2014–2015 school year at the earliest.
- Kansas is on a gradual four-year path toward implementation.
- Kentucky intends to begin K–12 implementation in 2014–2015.
- Maryland's preliminary plans for implementation do not fully introduce the standards until 2017–2018.
- Rhode Island's initial four-year implementation plan moves from awareness and understanding to curriculum shifts, then to instructional shifts, and finally to assessment systems.
- Vermont is in the process of establishing an advisory team to coordinate with the state's implementation team and communicate about the NGSS to stakeholders. Regional training meetings will continue through 2014. (News from Achieve, Sept. 2013)
- Delaware is proposing an assessment roll-out timeline that includes field testing new multi-dimensional items spring of 2016.
- D.C. expects to fully implement by 2016–2017.

Proposed Implementation Plan

The decision was made by the Arkansas State Board of Education on April 10, 2014 to endorse the NGSS which allows the Curriculum and Instruction unit, with stakeholder input, to move forward on a multi–year, comprehensive plan for the development and implementation of *Arkansas K-12 Science Standards*. The proposed implementation plan follows:

- 2012–2014 – Awareness and Understanding – Building a knowledge and understanding for the new standards
- 2014–2016 – Transition – Moving to the new standards
- 2016–2019 – Implementation – Putting standards into practice



Source: ADE, 2014

NGSS State Network

To support Arkansas and the adopting states, the NGSS Network will provide states support with technical assistance, expert advice, and opportunities to share best practices. A brief overview of the three-year, multistate project is below.

- EQuIP Rubric for Lessons & Units: Science
  The Educators Evaluating the Quality of Instructional Products (EQuIP) Rubric for science provides criteria by which to measure the alignment and overall quality of lessons and units with respect to the NGSS. The purpose of the rubric and review process is to: (1) provide constructive criterion-based feedback to developers; (2) review existing instructional materials to determine what revisions are needed; and (3) identify exemplars/models for teachers' use within and across states.
- Classroom Sample Assessment Tasks – Spring 2014
  - The Classroom Sample Assessment Tasks blend content, practices, and concepts from both the NGSS and the Common Core State Standards. Teachers across the disciplines have collaborated to write sample tasks, which are the result of a vision of integrating science, engineering, and mathematics in classroom assessment.
- State Standards Comparison Toolkit – Summer 2014
  The Science Standards Comparison Toolkit will support teachers and administrators in comparing the differences, both in purpose and content, between different sets of standards.

- NGSS Evidence Statements – Summer 2014
  NGSS Evidence Statements will provide educators with additional detail on what students should know and be able to do. These Evidence Statements are statements of observable and measureable components that, if met, will satisfy NGSS performance expectations.
- Accelerated Model Course Pathways – Summer 2014
  NGSS Accelerated Model Course Pathways provide examples of how the NGSS can be tailored for accelerated students. Created by Advanced Placement teachers, these models are designed to help schools and districts to envision pathways for students intending to take advanced science courses in their junior year.
- State of Science Education Research– Summer 2014
  The State of Science Education Research will present key findings on current state graduation requirements, course taking patterns, post-secondary institutions' course requirements for general entry and for entry into STEM-specific programs, and national job prospects in STEM fields. This research is designed to help inform and guide discussions about science education in the states.
- NGSS Data Portal – Summer 2014
  The NGSS data portal will let users search and view the NGSS to meet their individual needs for display on computers and mobile devices. This flexible resource will eventually allow users to tag and share resources.
- Alignment Institutes – Summer/Fall 2014
  Alignment Institutes will provide opportunities for K-12 and postsecondary educators to review the NGSS and discuss ideas for ensuring that the knowledge and skills learned in high school science courses will adequately prepare students for success in postsecondary education and careers.
- Publishers' Criteria – Fall 2014
  Publishers' Criteria will provide textbook and curricula developers with detailed information for using the NGSS to create high-quality, aligned instructional materials.
- NGSS Model Content Frameworks – Fall 2014
  To support educators and those developing curricula and instructional materials, the NGSS Model Content Frameworks will illustrate examples of how the NGSS could be organized over the course of the school year and across grade levels.
- STEM Works – Fall 2014
  This series of multimedia materials will provide case studies drawn from leading industries nationwide to illustrate the science knowledge and skills needed for jobs in STEM fields. The series will underscore the value of a rigorous science education for all students, regardless of their path after high school.

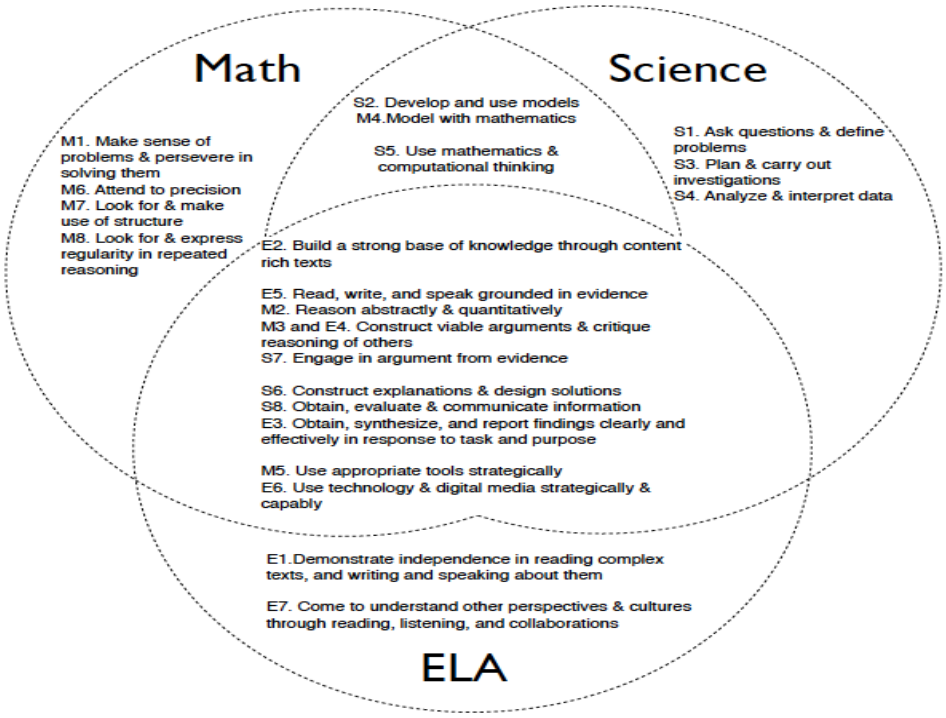
Considerations for Implementation

Voices from the field

ADE conducted an NGSS implementation survey in December 2013 to gather feedback from teachers (N=95), administrators (N=10), instructional facilitators (N=7), and a higher education instructor (N=1) in the field. Of the 197 educators surveyed, 113 responded to most of the questions. The respondents represented all grade levels from 61 school districts both small and large from all five ACTAAP regions. The field was surveyed on various topics related to the implementation of new content standards: awareness of current science education research, professional development, science curriculum framework documents, district/school level teaching and learning expectations, access to lab facilities and equipment, and the NGSS. The respondents overwhelmingly choose a gradual implementation plan as reflected in the science standards timeline. Refer to NGSS Adoption Implications Survey (Appendix O) for more details of the feedback received from the field.

Implementation of Common Core State Standards

NGSS supports the implementation of the CCSS. Integration of subject areas is an avenue that strengthens science learning for all students, particularly for students who have traditionally been underserved. One of the benefits of the NGSS is that these standards are already aligned to the *Common Core State Standards for ELA/Literacy* and *Common Core State Standards for Math*. The concurrent development in English Language Arts and Mathematics, under the CCSS, has provided the opportunity to build on the strengths of these literacy and math documents from a science education perspective (Stage et. al., 2013). When students are learning about science, they are also enhancing their skills in reading, writing, and math. In addition, the technology required for PARCC has the potential to enhance science instruction that meets the rigor of NGSS. The diagram below illustrates the relationships and convergences in literacy, math, and science and engineering practices.



Source: Understanding Language Initiative at Stanford University, (2013)

Instructional Materials

Because *A Framework for K–12 Science Education* has been available since 2011, publishers and educational support companies have already begun developing instructional materials that align to the scientific and engineering practices, crosscutting concepts, and the learning progressions of the disciplinary core ideas.

In addition to text–based resources, students need access to materials and equipment, much of which is consumable, to engage in rich hands-on science. The NGSS are written as student performance expectations (e.g., MS-LS1-1: Conduct an investigation to provide evidence that living things are made of cells; either one cell or many different numbers and types of cells. [Clarification Statement: Emphasis is on developing evidence that living things are made of cells, distinguishing between living and non-living cells, and understanding that living things may be made of one cell or many and varied cells.]). The bundling of NGSS performance expectations will engage students more deeply in hands–on, inquiry–based learning during units of study. Schools will need access to laboratory supplies; science and engineering manipulatives; instructional technology, including data–collection devices and software; and safety equipment in order to fully implement the NGSS. The education service cooperatives and STEM centers currently have some of these resources available, but cooperation in assisting schools with access to materials and training must be expanded. Survey data indicates that just over half of Arkansas teachers at Grade 8 have most of the resources they need to teach science. This percentage is low for science teachers in both Arkansas and the rest of the nation and is lower than the average for Arkansas math teachers (Change the Equation, 2013).

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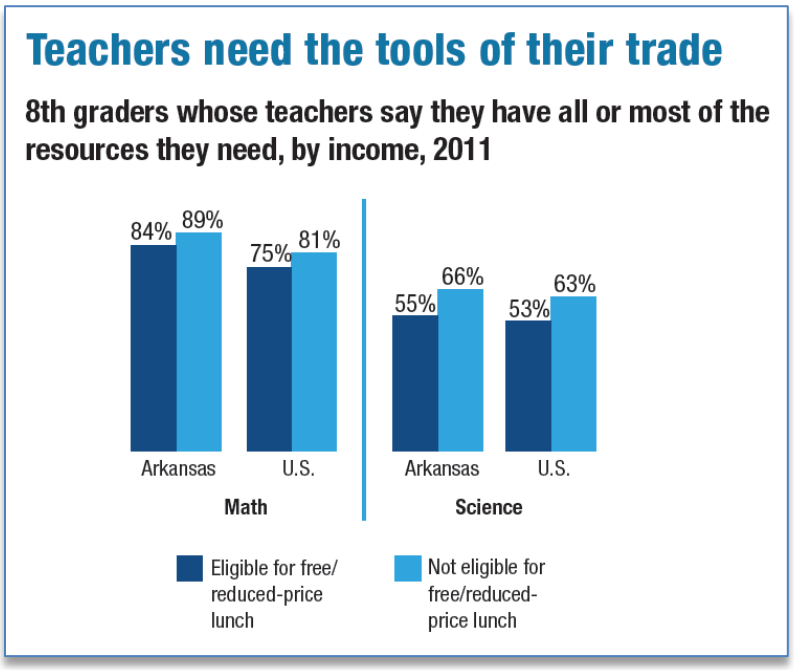


Source: Change the Equation, 2013

Science Assessment

Arkansas's science assessments are aligned to the current *Arkansas Science Curriculum Frameworks*. When new science standards are adopted, ADE will develop a multi–year plan that will address the need for assessments to measure the progress of student learning in science. The details of that process are yet to be determined. According to the Board on Testing and Assessment and the writers of *A Framework for K-12 Science Education* (NRC, 2012), most current forms of science assessment will not be appropriate for measuring the depth and breadth of the NGSS.

Arkansas has been a part of the discussion around science assessment for the past two years through the CCSSO–SCASS. During a recent Science Assessment Symposium, these very pertinent questions were posed:

1. How do we assess a wider range of competencies?
2. How do we achieve authenticity?
3. How do we assess understanding of the crosscutting concepts in science?
4. How do we incorporate the progression of science concepts?
5. How do we involve teachers?
6. What is the promise (and the pitfalls) of technology?
7. What is more important – assessments for formative purposes or assessments for summative purposes? (Osborne, 2013)

A recently published NRC report titled "*Developing Assessment for the Next Generation Science Standards*" attempts to answer these and many other questions, but the lessons learned through the development and implementation of assessments aligned to the CCSS will help to inform states as we move toward new science assessments. A consensus seems to exist in the science education community that it is too early to develop large–scale, summative science assessments aligned to the NGSS and that assessments should not get ahead of curriculum and instruction. Currently there is no assessment consortia around the NGSS and no funding anticipated for this work.

Professional Development

Quality professional development around the three dimensions of the NGSS–scientific and engineering practices, crosscutting concepts, and disciplinary core ideas will be an ongoing necessity. Teachers will need deeper content knowledge and instructional strategies to facilitate increased student–centered science investigation.

Professional development will need to follow the timeline discussed above. Professional development opportunities should include, at minimum, the following:

- the integration of science and engineering practices and crosscutting concepts with science content for several years
- engineering practices and the engineering design cycle for several years
- the use of formative assessments in science classrooms
- the use of models and constructing models from evidence

NGSS adopting states will work together as the NGSS Network to support the adoption and implementation of the standards through professional development. This work has already included monthly conference calls and will expand over the next three years to include annual leadership conferences and adoption and implementation institutes. The Council of State Science Supervisors will continue to sponsor Building Capacity in State Science Education. The National Science Teachers Association has already made multiple NGSS resources available (NGSS webinars, NGSS listserv). The goal is to collaborate on NGSS professional development tools and implementation strategies with other adopting states.

Science specialists affiliated with ADE, education service cooperatives, and STEM Centers have been conducting introductory professional development around *A Framework for K-12 Science Education* since 2012. These professional development opportunities have been well attended. Science specialists continue to develop and expand the range of science-specific professional development opportunities that focus on best practices and the big shifts in science instruction.

The professional development that has grown out of Arkansas's collaboration with Southern Regional Education Board on the Literacy Design Collaborative and Mathematics Design Collaborative support the application of several NGSS scientific and engineering practices, including constructing explanations and designing solutions,

using mathematics and computational thinking, and engaging in argument from evidence.

To prepare for the increasing emphasis on incorporating science and engineering practices in the curriculum, developing and/or making available safety training for science educators would be prudent. Partnering with STEM centers and Education Renewal Zones at institutions of higher education may be one way to facilitate the access to science education safety experts. Safety training will need to be a part of the long–term NGSS implementation plan.

Teacher Excellence and Support System (TESS)

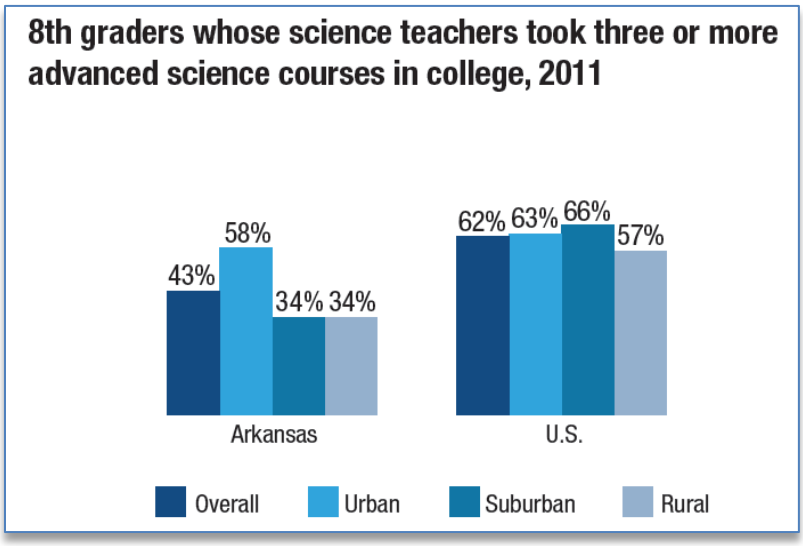
Arkansas has made a critical step toward ensuring high quality instruction and instructional leadership through the implementation of TESS. The table below provides examples of how the adoption and implementation of the NGSS can support Charlotte Danielson's *A Framework for Teaching* and TESS in Arkansas.

A Framework for Teaching	**NGSS Contributions**
1a Knowledge of Content and Pedagogy Accomplished teachers understand the internal relationships within the disciplines they teach, knowing which concepts and skills are prerequisite to the understanding of others. They are also aware of typical student misconceptions in the discipline and work to dispel them.	• The NGSS are built around science learning progressions. • The crosscutting concepts emphasize the connections between and among science concepts. • The NGSS science and engineering practices can also serve as a guide to necessary student skills.
3b Using Questioning and Discussion Techniques Questioning and discussion are the only instructional strategies specifically referred to in *A Framework for Teaching* and are of central importance.	NGSS science and engineering practices specifically require students to • ask questions, • construct explanations, • engage in argument from evidence, and • obtain, evaluate, and communicate information. The teacher will need to model appropriate questioning and discussion techniques to elicit students to apply these science and engineering practices effectively.

Source: *Enhancing Professional Practice: A Framework for Teaching* (Danielson, 2007)

Teacher Preparation

Arkansas's pre-service teacher preparation programs may not be providing teachers with adequate content knowledge and practice in the field. For example, the table below shows that Arkansas's Grade 8 science teachers may be less prepared to teach science than their national counterparts. A significantly lower percentage of Arkansas teachers at both rural and suburban schools completed less than three advanced science courses in college (Change the Equation, 2013).



Source: Change the Equation, 2013

Steps are being taken to address this issue, including recent changes in the requirements for middle school licensure. Rather than being generalists, middle school teachers will now select two areas of specialty (e.g., science and math) and take eighteen credit hours in each area. During 2012–13, The Office of Educator Effectiveness at ADE worked with a broad-based stakeholder committee to develop new competencies for elementary teachers in science for Grades K–6. These competencies are rigorous and designed around the three dimensions of *A Framework for K–12 Science Education* and the NGSS. In addition, the Praxis II science assessments, which are required for teacher licensure, will be revised to align with the NGSS. This congruency of Grades K–12 science content standards, teacher preparation, and licensure requirements is critical to the successful implementation of the NGSS in Arkansas.

Teacher Licensure

Licensure will be impacted in the following ways:

- Earth and space science content will be required in Grades K–12. This will specifically impact Grades 7–12 science content licensures. Currently, only an endorsement to licensure is available for the earth and space science content area. ADE science curriculum specialists are working with licensure to inform the

new Grades 7–12 licensure competencies. ETS is in the process of aligning Praxis exams to the NGSS, but that work could take at least three more years to complete, as it did with alignment to the CCSS.

Arkansas Standards for Accreditation

An amendment to the current ADE *Standards for Accreditation,* 9.0, Standard IV, Curriculum, may be required to address the following issues:

- The amount of time Grades K–8 students are engaged in science instruction is inadequate for the instruction of the NGSS. Currently, in Grades K-8, science is only required to be taught annually. Because the NGSS are designed as learning progressions that build student understandings and skills over Grades K–12, successful implementation will depend on an equal amount of time spent on science, mathematics, and ELA instruction.
- Natural science will need to be redefined. Science domains addressed in the NGSS are physical science, life science, and earth and space science. In Grades K–4 and Grade 5, Arkansas defines science domains as physical science systems, life science systems, earth and space science systems, and environmental education.
- Science for Grades 6–8 will need to be redefined. The NGSS are grade specific in Grades K–5, so no change will be required. However, the NGSS are grade banded in Grades 6–8. To support this change, the NGSS include Appendix K: Model Course Mapping in Middle and High School that provides several models of course pathways for use in creating courses. Currently Arkansas middle school science standards are an integration of three domains: life science, earth and space science, and physical science. However, committee work will be required to map the NGSS performance expectations into specific models for Grades 6, 7, and 8. This work was recently completed in California and will provide support to our work here in Arkansas.
- Science for Grades 9–12 will need to be redefined. Earth and space science standards will be required for the first time in high school courses in Arkansas. Currently, five units are required to be taught: biology, chemistry, physics, environmental science, and anatomy and physiology. Committees will be required to map high school course content. To support this change, the NGSS include Appendix K: Model Course Mapping in Middle and High School that provides several models of course pathways for use in creating courses.

Amendment of the current *Standards for Accreditation,* 14.0, Standard IX, Graduation Requirements regarding Smart Core and Core curricula may be required.

- The Smart Core requirement of three units of science with lab experience will need to be redefined. The NGSS in the Grades 9-12 grade band can be taught in three years, so there will be no need to change the number of science units required for graduation. A committee will be required to determine high school course titles and what NGSS standards will be bundled together to create three

high school courses that Smart Core/Core students will be required to take. The NGSS are the first set of college and career ready science standards as detailed in NGSS Appendix C: College and Career Readiness.

- To support this change, NGSS Accelerated Pathways are currently being developed by Advanced Placement (AP) teachers. These course models will provide examples of how NGSS can be tailored for accelerated students and will help schools and districts to envision pathways for students intending to take AP science courses in their junior and senior years.

Voices of Support

Across the country, business leaders, scientists, and educators recognize the essential importance of training in STEM in order to increase the United States' competitive edge. The NGSS meets that goal. A letter of support from many of these science education partners appears on the NGSS website (Appendix P). Additional support has been expressed by Arkansas-based partners, specifically the Arkansas Science Teachers Association (Appendix Q) and the Arkansas STEM Coalition (Appendix R).

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