Appendix J

K–12 NGSS Review Results

Grade Band: K–2

Standards:

K–PS2	Motion and Stability: Forces and Interactions
K–PS3	Energy
K–LS1	From Molecules to Organisms: Structures and Processes
K–ESS2	Earth's Systems
K–ESS3	Earth and Human Activity
1–PS4	Waves and their Applications in Technologies for Information Transfer
1–LS1	From Molecules to Organisms: Structures and Processes
1–LS3	Heredity: Inheritance and Variation of Traits
1–ESS1	Earth's Place in the Universe
2–PS1	Matter and its Interactions
2–LS2	Ecosystems: Interactions, Energy, and Dynamics
2–LS4	Biological Evolution: Unity and Diversity
2–ESS1	Earth's Place in the Universe
2–ESS2	Earth's Systems
K–2–ETS1	Engineering Design

A. Clarity and Specificity

The following questions and instructions were presented for consideration:

- Do you have a clear idea of what students must know and be able to do in early childhood?
- How open to interpretation are these standards? Support with evidence.
- Is it clear what is and is not included? Support with evidence.

    To answer these questions, think about whether the above elements in these standards are clear and specific enough for a classroom teacher to understand the outcomes expected and assess whether a student has met the outcomes specified in the standards. Base your answer on all of the information in each standard, including the performance expectations, foundation boxes, and connection box.

The following statements are a summary of the comments the Grades K–2 subcommittee submitted by consensus:

> Overall, the subcommittee agreed the Grades K–2 standards are clear and specific. The detailed information for what students need to know at the completion of kindergarten, Grade 1, and Grade 2 is clear and there is little open for interpretation. The science and engineering practices clarify the performance expectations. It is clear what is and is not included in this grade band of

standards. The performance expectations are understandable and not open to interpretation. The assessment boundaries are specific enough to help teachers understand what is required for student learning. The clarification statements greatly enhance the clarity of the performance expectations. However, mastery of a standard is not limited to the tasks listed in the clarification statements. The whole structure of the standards, including the organization, color coding, pop–ups, and scaffolding, supports a clear flow of information. Hyperlinks to *A Framework of K–12 Science Education* and the CCSS provide quick and easy background information to users.

The group had few concerns with the clarity and specificity of the Grades K–2 standards. While the standards are very clear, the subcommittee agreed it is important to know how to interpret the standards. The group expressed concern that the standards would require teachers to take students outside the classroom for observations and that parents would have to be engaged in order for students to make observations of nighttime events or patterns.

B. Integrated Performance Expectations

The following questions were presented for consideration:

- In what ways can the inclusion of all three components in a single expectation lead to improved learning of the core idea? Be as specific as you can.
- Overall, is there a clear connection between the performance expectations and the science and engineering practices, disciplinary core ideas, and crosscutting concepts in the foundation box? Be as specific as you can.
- Is it reasonable to assume that a student who has successfully completed the performance expectations has achieved mastery of the disciplinary core ideas? science and engineering practices? Crosscutting concepts?

The following statements are a summary of the comments the Grades K–2 subcommittee submitted by consensus:

Overall, the inclusion of all three dimensions (science and engineering practices, crosscutting concepts, and disciplinary core ideas) in each performance expectation in the Grades K–2 standards leads to improved learning of the disciplinary core ideas. The connections between the performance expectations and the science and engineering practices, disciplinary core ideas, and crosscutting concepts are clear. For example, planning and carrying out investigations is an appropriate scientific practice for the performance expectation of “providing evidence that vibrating materials can make sound and that sound can make materials vibrate” and the crosscutting concept of cause and effect is also appropriate to explain the phenomenon. Users are easily directed to the other three dimensions which expand the learning. The assessment boundaries clearly dictate what should be completed in order to master the science and engineering practices, crosscutting concepts, and the disciplinary core ideas at the end each grade.

It is reasonable to assume that students in Grades K-2 could achieve mastery of these Grades K–2 performance objectives. The objective at this level of learning is to establish a foundation for the Grades K–2 performance expectations. The primary focus is, appropriately, at the qualitative level. However, it is not reasonable to assume a student has achieved mastery of the science and engineering practices and crosscutting concepts because these are skills that require extended experiences to master.

The subcommittee identified two concerns with the integration of the performance expectations in the Grades K–2 grade band. First, the Grade 2 Life Science Standard Four (LS4) lacks a crosscutting concept, and leaving one of the dimensions in the foundation box empty may lead users to think that extended learning is not necessary. Second, the online version does not make it readily evident that the pop–ups exist. These pop–ups are an important feature that define the three dimensions for the user.

C. Learning Progressions within the Grade–Band

The following questions were presented for consideration:

- Is there evidence that the standards led to increasing sophistication of student thinking? Support your answer with evidence.

The following statements are a summary of the comments the K–2 subcommittee submitted by consensus:

The Grades K–2 standards lead to increasing sophistication of student thinking over the grade band. In kindergarten, the emphasis is on observation. By Grade 1, students engage in more research and data collection. In Grade 2, students engage in argumentation to defend their explanations and plan and conduct investigations.

D. Achievability and Preparedness

The following questions were presented for consideration:

- Would students who achieve the tasks described in these standards be ultimately be prepared for success at college and/or in their careers? Support your answer with evidence.
- Are the tasks described in the performance expectations reasonable expectations for all students? (refer to The Next Generation Science Standards Appendix D: All Standards, All Students)

To answer these questions, think about what students need to know and be able to do to be successful in life and also consider the time and effort needed to help all students achieve the stated expectations.

The following statements are a summary of the comments the K–2 subcommittee submitted by consensus:

The Grades K–2 standards should ultimately prepare students to progress to the next grade band. The Grades K–2 standards lay the foundation for scientific and mathematical habits of mind. Based on the research found in The Next Generation Science Standards Appendix D: All Standards, All Students, the student tasks are appropriate in the Grades K–2 performance expectations.

E. Instructional Implications of the Standards

The following questions were presented for consideration:

- Do you think that these standards provide enough guidance to curriculum developers and educators to determine instructional sequences and instructional strategies? Why or why not?

The following statements are a summary of the comments the Grades K–2 subcommittee submitted by consensus:

These standards provide enough guidance to curriculum developers and educators to determine instructional sequences and strategies because there is a definite scope and sequence in the Grades K–2 standards. The science and engineering practices and crosscutting concepts guide instruction while allowing the freedom of creativity to teachers.

F. Scientific and Engineering Practices

The following questions were presented for consideration:

- Are the science and engineering practices represented with enough frequency in the grade band that students will have the opportunity to master the practice by the end of that grade band? Support your answer with evidence.

The following statements are a summary of the comments the K–2 subcommittee submitted by consensus:

At this grade band, all level-appropriate science and engineering practices are incorporated with enough frequency.

G. Crosscutting concepts

The following questions were presented for consideration:

- Are the crosscutting concepts represented with enough frequency so that students will understand them as crosscutting all the disciplines within science, and not relevant to just some areas of science (life science, earth science, physical science, engineering and technology)? Support your answer with evidence.
- Will the inclusion of these crosscutting concepts deepen the understanding of science and engineering concepts? Why or why not?

The following statements are a summary of the comments the K–2 subcommittee submitted by consensus:

> Patterns and cause and effect are well represented with enough frequency so that students will understand them while forming a solid foundation for further instruction in later grades. The inclusion of these crosscutting concepts deepen the understanding of science and engineering concepts because students engage in connecting multiple science concepts and domains as connected ideas.

H. Engineering Design

The following questions were presented for consideration:

- Will the inclusion of these engineering design standards deepen student understanding of science concepts? Why or why not?

The following statements are a summary of the comments the K–2 subcommittee submitted by consensus:

> Engineering design standards deepen student understanding by engaging them in authentic problem solving.

I. Connections

The following questions were presented for consideration.

- How will the inclusion of connections to the CCSS for ELA/Literacy affect instruction?
- How will the inclusion of connections to the CCSS for Math affect instruction?
- How will the connections to other disciplinary core ideas in this grade band affect instruction?
- How will the articulations of disciplinary core ideas across grade bands affect instruction?

The following statements are a summary of the comments the K–2 subcommittee submitted by consensus.

> The inclusion of the connections to the CCSS for ELA/Literacy and math show teachers where literacy and math can be rigorously taught through the science standards.

J. Utility

The following questions were presented for consideration:

- Please share your comments or concerns about the usability of the
    - online version of the NGSS overall,
    - sort by performance expectation function,

- hyperlinks between and within the document,
- PDF version by disciplinary core ideas,
- PDF version by topic, and
- the appendices.

The following statements are a summary of the comments the K–2 subcommittee submitted by consensus:

> The subcommittee agreed teachers would benefit from using the online version of the NGSS standards because of the pop–up applications. The online version is the best way to use all the components of the NGSS. The sort by performance expectation function and the hyperlinks between and within the document are very helpful for curriculum development. The PDF version organized by disciplinary core idea is user-friendly. The PDF version organized by topic helps to organize learning progressions and to align curriculum. The appendices provide a wealth of supporting information, background knowledge, and usability.

Grade Band: 3–5

Standard:

3–PS2	Motion and Stability: Forces and Interactions
3–LS1	From Molecules to Organisms: Structures and Processes
3–LS2	Ecosystems: Interactions, Energy, and Dynamics
3–LS3	Heredity: Inheritance and Variation of Traits
3–LS4	Biological Evolution: Unity and Diversity
3–ESS2	Earth's Systems
3–ESS3	Earth and Human Activity
4–PS3	Energy
4–PS4	Waves and their Applications in Technologies for Information Transfer
4–LS1	From Molecules to Organisms: Structures and Processes
4–ESS1	Earth's Place in the Universe
4–ESS2	Earth's Systems
4–ESS3	Earth and Human Activity
5–PS1	Matter and its Interactions
5–PS2	Motion and Stability: Forces and Interactions
5–PS3	Energy
5–LS1	From Molecules to Organisms: Structures and Processes
5–LS2	Ecosystems: Interactions, Energy, and Dynamics
5–ESS1	Earth's Place in the Universe
5–ESS2	Earth's Systems
5–ESS3	Earth and Human Activity
3–5–ETS1	Engineering Design

A. Clarity and Specificity

The following questions and instructions were presented for consideration:

- Do you have a clear idea of what students must know and be able to do in elementary school?
- How open to interpretation are these standards? Support with evidence.
- Is it clear what is and is not included? Support with evidence.

  To answer these questions, think about whether the above elements in these standards are clear and specific enough for a classroom teacher to understand the outcomes expected and assess whether a student has met the outcomes specified in the standards. Base your answer on all of the information in each standard, including the performance expectations, foundation boxes, and connection box.

The following statements are a summary of the comments the Grades 3–5 subcommittee submitted by consensus:

> Overall, it is clear what students must know and be able to do by the end of Grades 3, 4, and 5. In the engineering performances expectations, it is clear students have to make a claim or assess how a model works, but they do not have to create the solution themselves. In addition, an asterisk is used to clearly note a performance expectation as an engineering expectation. The clarification statements provide examples of possible student expectations to users. However, even though a few of the Grades 3–5 standards are missing clarification statements, the core ideas included in those performance expectations clear up what it is students need to know and be able to do. These standards are more open to interpretation allowing the instructor/student to use materials of choice to perform investigations. For example, the Grades 3–5 life science standards provide room for teachers to choose any plant or any animal to study. It is clear what is and is not included in the performance expectations when the assessment boundaries and clarification statements are considered.
>
> The Grades 3–5 subcommittee had no concerns with clarity and specificity. The NGSS take what children implicitly do when they are young during their early explorations and make the steps explicit and clear. It is an important skill, but not one that is typically explicitly taught. Even though the performance expectations are written clearly, there is room for interpretation in some of the Grades 3–5 standards. For example, in Grade 3, Earth and Space Science, Standard 2 (3-ESS2), students collect data during a particular season that is not specified.

B. Integrated Performance Expectations

The following questions were presented for consideration:

- In what ways can the inclusion of all three components in a single expectation lead to improved learning of the core idea? Be as specific as you can.

- Overall, is there a clear connection between the performance expectations and the science and engineering practices, disciplinary core ideas, and crosscutting concepts in the foundation box? Be as specific as you can.

- Is it reasonable to assume that a student who has successfully completed the performance expectations has achieved mastery of the disciplinary core ideas? Science and engineering practices? Crosscutting concepts?

The following statements are a summary of the comments the Grades 3–5 subcommittee submitted by consensus:

> Overall, the inclusion of all three dimensions in a single expectation leads to improved learning of the disciplinary core ideas in the Grades 3, 4, and 5 standards. For example, improved learning is facilitated when students are presented with patterns in the earth science standards on landform features and the cause and effects relationships of weathering and erosion. By addressing both simultaneously, students can gain a better understanding of patterns and how they are represented on maps. This potentially allows for student analysis and interpretation of map data as a science and engineering practice. Overall, there is a clear connection between the performance expectations, the science and engineering practices, disciplinary core ideas, and crosscutting concepts in the foundation boxes in the 3–5 grade band. Performance expectations are appropriate for the science and engineering practices, core ideas, and crosscutting concepts, and tie to STEM applications and societal issues. It is evident to teachers that the science and engineering practices make sense of the crosscutting concepts and together the three dimensions build student understanding of the core ideas over time. For example, as students interpret data (science and engineering practice) they make sense of cause and effect (crosscutting concept), making the connection of how or why certain animals or plants are no longer present on earth (disciplinary core idea). In addition, students are presented with many local examples of weathering and erosion in the clarification statements to connect to student prior experiences. The integration and connections are coherent.
>
> The subcommittee agreed that students who engage in these performance expectations could be on their way to mastering the disciplinary core ideas, but argue that students would need to repeat the performance expectations to do so. Completing expectations once does not infer mastery, but could be a good indication of a student’s level of understanding. Completing tasks in one performance expectation does not mean that students have mastered the science and engineering practices or the crosscutting concepts. Students need to replicate.
>
> There are no concerns about the integration of the performance expectations in the 3–5 grade bands.

C. Learning Progressions within the Grade Band

The following questions were presented for consideration:

- Is there evidence that the standards led to increasing sophistication of student thinking? Support your answer with evidence.

The following statements are a summary of the comments the Grades 3–5 subcommittee submitted by consensus:

> There is evidence that these standards lead to increasing sophistication of student thinking over K–12. For example, the Grades 3-5 performance expectations for Life Science (LS1) progress each year in rigor. Grade 3 students describe organisms and their life cycles, and Grade 4 students model systems and senses within organisms. In addition, students identify structures within each organism that support survival. In Grade 5, the students must support an argument about how plants get materials for growth, primarily from the air and water. The same progression is noted within the physical science and the earth and space systems standards within this grade band.

D. Achievability and Preparedness

The following questions were presented for consideration:

- Would students who achieve the tasks described in these standards be ultimately be prepared for success at college and/or in their careers? Support your answer with evidence.
- Are the tasks described in the performance expectations reasonable expectations for all students? (refer to The Next Generation Science Standards Appendix D: All Standards, All Students)

  To answer these questions, think about what students need to know and be able to do to be successful in life and also consider the time and effort needed to help all students achieve the stated expectations.

The following statements are a summary of the comments the Grades 3–5 subcommittee submitted by consensus:

> Students who achieve the tasks described in these standards should be ultimately prepared for success in future grades. Understanding cause and effect, designing solutions, and evaluating potential limitations are all skills needed throughout life. Achievement of these standards at this level is a necessary building block to prepare students for more comprehensive evaluations and investigations. Together, the NGSS and the CCSS standards should better prepare all students.
>
> The tasks described in the performance expectations are reasonable expectations for all students according to the research included in The Next

Generation Science Standards Appendix D: All Standards, All Students. For example, all students need to know as citizens how energy resources are used, what effects they have on the environment, and the methods to reduce impacts.

E. Instructional Implications of the Standards

The following questions were presented for consideration:

- Do you think that these standards provide enough guidance to curriculum developers and educators to determine instructional sequences and instructional strategies? Why or why not?

The following statements are a summary of the comments the Grades 3–5 subcommittee submitted by consensus:

> The science and engineering practices are represented with enough frequency in the 3–5 grade band. Students engage more deeply than in the previous grade bands in developing and using models, planning and carrying out investigations, constructing explanations, and engaging in argument from evidence. Asking questions and defining problems, and obtaining, evaluating, and communicating information appear with less frequency.
>
> Asking questions and defining problems as a scientific and engineering practice will need to be emphasized in professional development as an implied practice. Obtaining and communicating information should also be included more, but the CCSS for literacy will address this deficiency. This scientific and engineering practice also provides an opportunity for interdisciplinary collaboration between educators which will strengthen concepts and skills.

F. Scientific and Engineering Practices

The following questions were presented for consideration.

- Are the science and engineering practices represented with enough frequency in the grade band that students will have the opportunity to master the practice by the end of that grade band? Support your answer with evidence.

The following statements are a summary of the comments the 3–5 subcommittee submitted by consensus:

> Students make relative comparisons in Grades 3 and 4 and quantitative comparisons in the Grade 5. Developing and using models, planning and carrying out investigations, constructing explanations, and engaging in argument from evidence are adequately covered science and engineering practices. Asking questions and defining problems and obtaining, evaluating, and communicating information are included less commonly as science and engineering practices. These practices provide an opportunity for interdisciplinary collaboration between educators.

G. Crosscutting Concepts

The following questions were presented for consideration:

- Are the crosscutting concepts represented with enough frequency so that students will understand them as crosscutting all the disciplines within science, and not relevant to just some areas of science (life science, earth science, physical science, engineering and technology)? Support your answer with evidence.
- Will the inclusion of these crosscutting concepts deepen the understanding of science and engineering concepts? Why or why not?

The following statements are a summary of the comments the Grades 3–5 subcommittee submitted by consensus:

> The crosscutting concepts are represented with enough frequency. Patterns and cause and effect are well represented across all grades. System and system models progressively increased from Grades 3 to 5.
>
> Energy and matter, structure and function, and stability and change are not included in the performance expectations as often because these concepts are not developmentally appropriate for student learning at this grade band. These crosscutting concepts were addressed in Grades K–2 and then picked up again in Grades 6–8.
>
> The inclusion of these crosscutting concepts deepens the understanding of science and engineering concepts because these crosscutting concepts help engage students in a deeper understanding of the core ideas. Without crosscutting concepts students may rely on memory or factoid information and may not gain critical understanding of the content.

H. Engineering Design

The following questions were presented for consideration:

- Will the inclusion of these engineering design standards deepen student understanding of science concepts? Why or why not?

The following statements are a summary of the comments the Grades 3–5 subcommittee submitted by consensus:

> Science answers questions and engineering solves problems. The inclusion of these engineering design standards deepen student understanding of science concepts. Engineering design makes the learning practical for real–world application.

I. Connections

The following questions were presented for consideration:

- How will the inclusion of connections to the CCSS for ELA/Literacy affect instruction?
- How will the inclusion of connections to the CCSS for Math affect instruction?
- How will the connections to other disciplinary core ideas in this grade band affect instruction?
- How will the articulations of disciplinary core ideas across grade bands affect instruction?

The following statements are a summary of the comments the Grades 3–5 subcommittee submitted by consensus:

> The inclusion of the connections to the CCSS for ELA/Literacy increases the amount of time students read informational texts across disciplines. Coupled with hands–on activities, this can increase the comprehension level for all students. While reading texts that are increasing in complexity, students foster academic vocabulary skills and write arguments using evidence from texts.
>
> The inclusion of the connections to the CCSS for Math complements science instruction because math is relevant to science in everyday life. Math and science teachers both teach measurement and data collection. Students have the opportunity to realize that math is a huge part of science.
>
> The connections to other disciplinary core ideas in this grade band engage students in opportunities to connect science learning to many different disciplines within the realm of science.
>
> The articulations of the disciplinary core ideas across grades can impact instruction because they are like a GPS for science instruction. The articulations show exactly where students have been in previous grades and exactly where they are heading. Articulation of disciplinary core ideas should make it easier for teachers to coordinate across grade–levels.

J. Utility

The following questions were presented for consideration:

- Please share your comments or concerns about the usability of the
  - online version of the NGSS overall,
  - sort by performance expectation function,
  - hyperlinks between and within the document,
  - PDF version by disciplinary core ideas,
  - PDF version by topic, and
  - the appendices.

The following statements are a summary of the comments the Grades 3–5 subcommittee submitted by consensus.

The subcommittee agreed the online version is great for teachers because there are multiple ways to view the standards, both by disciplinary core idea and topic. The performance expectations are interactive. It is very teacher–friendly. The online version makes the NGSS more accessible and portable. There are some editorial inconsistencies between the PDF and interactive versions. The standards can also be sorted by performance expectation.

The hyperlinks between and within the document are very helpful and easy to use. The PDF versions by topic and disciplinary core idea are user–friendly and easily downloaded. The appendices are invaluable tools for curriculum development.

Grade Band: Grades 6–8 (Middle School)

Standard:

MS–PS1	Matter and Its Interactions
MS–PS2	Motion and Stability: Forces and Interactions
MS–PS3	Energy
MS–PS4	Waves and their Applications in Technologies for Information Transfer
MS–LS1	From Molecules to Organisms: Structures and Processes
MS–LS2	Ecosystems: Interactions, Energy, and Dynamics
MS–LS3	Heredity: Inheritance and Variation of Traits
MS–LS4	Biological Evolution: Unity and Diversity
MS–ESS1	Earth's Place in the Universe
MS–ESS2	Earth's Systems
MS–ESS3	Earth and Human Activity
MS–ETS1	Engineering Design

A. Clarity and Specificity

The following questions and instructions were presented for consideration:

- Do you have a clear idea of what students must know and be able to do in middle school?
- How open to interpretation are these standards? Support with evidence.
- Is it clear what is and is not included? Support with evidence.

To answer these questions, think about whether the above elements in these standards are clear and specific enough for a classroom teacher to understand the outcomes expected and assess whether a student has met the outcomes specified in the standards. Base your answer on all of the information in each standard, including the performance expectations, foundation boxes, and connection box.

The following statements are a summary of the comments the Grades 6–8 subcommittee submitted by consensus:

> Overall, it is clear what students must know and be able to do in the middle school standards. The standards are direct, easy, creative, and measurable. The clarification statements provide examples and guidance for users when the standards might be open to interpretation. In addition, the assessment boundaries are necessary and easily applied to lab investigations.
>
> The subcommittee agreed the performance expectations in this grade band are clear and clarify the content to be delivered. For example, in the Middle School Earth and Space Science, Standard 3, (MS–ESS3), students predict the connections between weather, atmosphere, and environmental hazards. Students ask and answer questions and design ways to monitor and minimize impacts on humans. The life science standards offer many interesting possibilities for teaching. The physical science standards are also clear. For example, in the Middle School Physical Science, Standard 3, (MS–PS3), the performance expectations use verbs engaging students in higher level thinking skills.
>
> The subcommittee found some concerns with the middle school standards. For example, the Middle School Engineering Design, Standard One, (MS–ETS1) is very open to interpretation because there are no clarification statements or assessment boundaries. A definition of student success is not apparent because building a bridge does not denote success; success would be measured as to how well the bridge functions.
>
> In addition, students will need to come into middle school with a foundational knowledge and understanding of the Grades K–5 standards in order to be successful. The middle school standards are grade–banded and not delineated into specific grades. These performance expectations are what students need to know and be able to do at the end of Grade 8 instruction. For example, the physical science middle school standards may contain the largest shift in increased rigor, content, and student learning. Students are engaged often in the design and use of models.

B. Integrated Performance Expectations

The following questions were presented for consideration:

- In what ways can the inclusion of all three components in a single expectation lead to improved learning of the core idea? Be as specific as you can.
- Overall, is there a clear connection between the performance expectations and the science and engineering practices, disciplinary core ideas, and crosscutting concepts in the foundation box? Be as specific as you can.
- Is it reasonable to assume that a student who has successfully completed the performance expectations has achieved mastery of the disciplinary core ideas? Science and engineering practices? Crosscutting concepts?

The following statements are a summary of the comments the Grades 6–8 subcommittee submitted by consensus:

> The inclusion of all three dimensions in each performance expectation can lead to improved learning of the disciplinary core ideas because the performance expectations take learning to a deeper level with the science and engineering practices (hands–on projects and analysis of data). These three components provide ways for students to apply the knowledge/skills, thereby enhancing the learning. Higher level thinking skills and problem solving are addressed in the performance expectations.
>
> Overall, there is a clear connection between the performance expectations and the science and engineering practices, disciplinary core ideas, and crosscutting concepts in the foundation boxes. For example, Middle School Life Science, Standard 2, (MS–LS2) shows connections with cause and effect relationships, microscopic structures, and functions within systems. The foundation boxes contain links to additional information and the hyperlink feature to *A Framework for K-12 Science Education* is very useful. There is also a direct link to standards and skills from prior years.
>
> If a student has successfully completed these standards, they may have mastered the middle school topics. Mastery is more clearly defined in The Next Generation Science Standards Appendix E: Disciplinary Core Idea Progressions within NGSS.

C. Learning Progressions within the Grade Band

The following questions were presented for consideration:

- Is there evidence that the standards led to increasing sophistication of student thinking? Support your answer with evidence.

The following statements are a summary of the comments the Grades 6–8 subcommittee submitted by consensus:

> There is evidence that the standards lead to increasing sophistication of student thinking. Considering the verbs and language within the standards, there is a progression built into the performance expectations. *A Framework for K–12 Science Education* (NRC, 2012) contains learning progressions for the grade band endpoints. There are also charts of learning progressions in the appendices which are very helpful in articulating the standards within the grade band. The verbs address progressively higher levels of thinking.

D. Achievability and Preparedness

The following questions and instructions were presented for consideration:

- Would students who achieve the tasks described in these standards be ultimately be prepared for success at college and/or in their careers? Support your answer with evidence.
- Are the tasks described in the performance expectations reasonable expectations for all students? (refer to The Next Generation Science Standards Appendix D: All Standards, All Students)

  To answer these questions, think about what students need to know and be able to do to be successful in life and also consider the time and effort needed to help all students achieve the stated expectations.

The following statements are a summary of the comments the Grades 6–8 subcommittee submitted by consensus:

> Students who achieve the tasks described in these standards will be on a continuum of learning. Middle school students are stil building their foundation in Grades 6–8 for the high school learning experience. Students are learning the science and engineering practices and are on their way to becoming college and career ready. These standards can prepare students to become lifelong learners.
>
> If teachers make recommended modifications (e.g., IEP, 504, ELL) and properly scaffold, then all students will be able to meet the expectations. The Next Generation Science Standards Appendix D: All Standards, All Students gives many strategies for science instruction for all students.

E. Instructional Implications of the Standards

The following questions were presented for consideration:

- Do you think that these standards provide enough guidance to curriculum developers and educators to determine instructional sequences and instructional strategies? Why or why not?

The following statements are a summary of the comments the Grades 6–8 subcommittee submitted by consensus:

> The subcommittee had some concerns about the instructional implications of the middle school grade band. These middle school standards do not provide enough guidance to curriculum developers and educators to determine instructional sequences and strategies because there are no specific grade expectations.

F. Scientific and Engineering Practices

The following questions were presented for consideration:

- Are the science and engineering practices represented with enough frequency in the grade band that students will have the opportunity to master the practice by the end of that grade band? Support your answer with evidence.

The following statements are a summary of the comments the Grades 6–8 subcommittee submitted by consensus:

> The science and engineering practices are represented with enough frequency in the grade band to master the science and engineering practices by the end of middle school. Students are provided with multiple opportunities to engage with the science and engineering practices across the standards. These standards are the floor of knowledge and skills and are not the ceiling.

G. Crosscutting Concepts

The following questions were presented for consideration:

- Are the crosscutting concepts represented with enough frequency so that students will understand them as crosscutting all the disciplines within science, and not relevant to just some areas of science (life science, earth science, physical science, engineering and technology)? Support your answer with evidence.
- Will the inclusion of these crosscutting concepts deepen the understanding of science and engineering concepts? Why or why not?

The following statements are a summary of the comments the Grades 6–8 subcommittee submitted by consensus:

> The crosscutting concepts are represented with enough frequency to foster greater understanding. For example, structure and function, cause and effect, and systems and system models are concepts that provide students with a clear understanding of systems across the all science domains. Science thinking skills are part of daily life and the inclusion of these concepts make it easier for students to understand why they need science. Science is a process of decision making rather than a body of knowledge; there is interconnectedness across multiple disciplines. For example, the earth and space science standards reference global impacts such as how fish are impacted as sea levels rise. In the life science standards, the crosscutting concepts help students to understand that the environment affects the adaptation and natural selection of organisms over generations.

H. Engineering Design

The following questions were presented for consideration:

- Will the inclusion of these engineering design standards deepen student understanding of science concepts? Why or why not?

The following statements are a summary of the comments the Grades 6–8 subcommittee submitted by consensus:

> The inclusion of these engineering design standards deepen student understanding of science concepts because students are engaged in applying their knowledge at a deeper level, using the design process to understand and use knowledge in real world applications.

I. Connections

The following questions were presented for consideration:

- How will the inclusion of connections to the CCSS for ELA/Literacy affect instruction?
- How will the inclusion of connections to the CCSS for Math affect instruction?
- How will the connections to other disciplinary core ideas in this grade band affect instruction?
- How will the articulations of disciplinary core ideas across grade bands affect instruction?

The following statements are a summary of the comments the Grades 6–8 subcommittee submitted by consensus:

> The inclusion of the connections to the CCSS for ELA/Literacy affects instruction positively. Disciplinary literacy which encompasses reading within the content areas as well as writing for a purpose (writing arguments and information/explanatory writing) enhance science content and provide structure for the content. Increased text complexity better prepares students for college and career.
>
> The inclusion of connections to the CCSS for mathematics affects instruction positively. Students have limited experience interpreting and analyzing data on graphs, tables, and charts. The connections between the CCSS and the NGSS help to assure students are prepared for college and careers because content does not exist in isolation; rather it overlaps in all the content areas.
>
> The connections to other disciplinary core ideas in this grade band bring real world connections to student learning experiences. The articulations of the disciplinary core ideas across grade–levels enhance vertical and horizontal alignment within and across grades to assure content is the same.

J. Utility

The following questions were presented for consideration:

- Please share your comments or concerns about the usability of the
  - online version of the NGSS overall,
  - sort by performance expectation function,
  - hyperlinks between and within the document,
  - PDF version by disciplinary core ideas,
  - PDF version by topic, and
  - the appendices.

The following statements are a summary of the comments the Grades 6–8 subcommittee submitted by consensus:

> The usability of the online version of the NGSS, Sort by Performance Expectation function, hyperlinks between and within the document, PDF versions by disciplinary core ideas and by topic, and the appendices are all user-friendly.

Grade Band: 9–12 (High School)

Standard:

HS–PS1	Matter and Its Interactions
HS–PS2	Motion and Stability: Forces and Interactions
HS–PS3	Energy
HS–PS4	Waves and their Applications in Technologies for Information Transfer
HS–LS1	From Molecules to Organisms: Structures and Processes
HS–LS2	Ecosystems: Interactions, Energy, and Dynamics
HS–LS3	Heredity: Inheritance and Variation of Traits
HS–LS4	Biological Evolution: Unity and Diversity
HS–ESS1	Earth's Place in the Universe
HS–ESS2	Earth's Systems
HS–ESS3	Earth and Human Activity
HS–ETS1	Engineering Design
HS–ESS1	Earth's Place in the Universe

A. Clarity and Specificity

The following questions and instructions were presented for consideration:

- Do you have a clear idea of what students must know and be able to do in high school?
- How open to interpretation are these standards? Support with evidence.
- Is it clear what is and is not included? Support with evidence.

> To answer these questions, think about whether the above elements in these standards are clear and specific enough for a classroom teacher to understand the outcomes expected and assess whether a student has met the outcomes specified in the standards. Base your answer on all of the information in each standard, including the performance expectations, foundation boxes, and connection box.

The following statements are a summary of the comments the Grades 9–12 subcommittee submitted by consensus:

Overall, the high school standards are clear about what students are expected to know by the end of Grade 12. The earth and space science, life science, and the physical science standards have very clear performance expectations and include clarification statements and assessment boundaries. Some of the performance expectations in this grade band may require a stronger chemistry background to master. In the engineering design standards, the high school performance expectations lack assessment boundaries and clarification statements. Although the openness can be an advantage, it can be a disadvantage when it comes time for assessment.

The earth and space science, life science, and the physical science standards are generally not open to interpretation. The high school standards are clearly stated with room for extension and allow for a variety of methods and teaching strategies to address all learning styles and all learning levels of students.

The group expressed concerns on the clarity and specificity in the high school grade band standards. For example, there are many high school standards that specifically ask students to use models to master the performance expectation. However, the performance expectations using this scientific and engineering practice may be more open to interpretation when the type of model (e.g., conceptual, mathematical, computational) is left up to the student and/or teacher. The group also expressed some concerns about the depth of instruction in statistical analysis. The concern is that the mathematics and computational thinking required in a few of the life science performance expectations go beyond the three–year scope of math courses. In addition, the NGSS engage students in using computer simulations that require specific technology access and usability.

B. Integrated Performance Expectations

The following questions were presented for consideration:

- In what ways can the inclusion of all three components in a single expectation lead to improved learning of the core idea? Be as specific as you can.
- Overall, is there a clear connection between the performance expectations and the science and engineering practices, core ideas, and crosscutting concepts in the foundation box? Be as specific as you can.
- Is it reasonable to assume that a student who has successfully completed the performance expectations has achieved mastery of the disciplinary core ideas? Science and engineering practices? Crosscutting concepts?

The following statements are a summary of the comments the Grades 9–12 subcommittee submitted by consensus:

The inclusion of the three dimensions (science and engineering practices, crosscutting concepts, and disciplinary core ideas) in the high school performance expectations lead to improved learning of the disciplinary core ideas. For example, all of the performance expectations within the life science standards are directly linked to and supportive of one another as learning is progressive over high school coursework. For example in High School Earth and Space Science, Standard 3, (HS–ESS3), the math and quantitative analysis science and engineering practice engages students in solving natural phenomena and engineering problems by providing relevance to the student's real world experiences. In addition, the High School Physical Science, Standard 1, (HS–PS1) engages students in applying the crosscutting concepts and science and engineering practices to the physical science disciplinary core ideas. One of the performance expectations asks students to use the periodic table as a model and to identify patterns. In turn, students gain a deeper understanding of the structures of matter and their interactions.

Overall, there is a clear connection between the performance expectations and the science and engineering practices, core Ideas, and crosscutting concepts in the foundation boxes. The foundation boxes contain cross references to the performance expectations because the boxes explain the science and engineering practices, crosscutting concepts, and disciplinary core ideas as defined in *A Framework for K–12 Science Education*. Therefore, by defining the exact science and engineering practices, crosscutting concepts, and disciplinary core ideas referenced in each performance expectation of a standard, the foundation boxes better clarify what students must know and be able to do. For example, in High School Earth and Space Science, Standard 3, (HS–ESS3–3), students "create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity." The foundation boxes contain pop–up explanations of constructing explanations and designing solutions and using mathematics and computational thinking, the crosscutting concept of stability and change, and the disciplinary core idea of human impacts on Earth systems. Each explanatory component in the foundation boxes is directly linked to the performance expectations by the standard code (HS–ESS3–3).

Is it reasonable to assume that a student who has successfully completed the high school performance expectations has achieved mastery of the disciplinary core ideas, science and engineering practices, and crosscutting concepts to the rigor dictated by *A Framework for K–12 Science Education*? This is assuming the student has progressed through all four domains (earth and space science, life science, and physical science) with fidelity across Grades K–12.

C. Learning Progressions within the Grade Band

The following questions were presented for consideration:

- Is there evidence that the standards led to increasing sophistication of student thinking? Support your answer with evidence.

The following statements are a summary of the comments the Grades 9–12 subcommittee submitted by consensus:

It is difficult to identify evidence that the standards lead to increasing sophistication of student thinking because they are written as a grade band of standards. Previous endpoints must be taken into consideration for instruction. If the students meet the standards, it is reasonable to assume that there is an increased sophistication of student thinking. For example, in High School Earth and Space Science, Standard 2, (HS–ESS2), there is a progression from comprehension to synthesis in the performance expectations. There are many such examples throughout the NGSS.

D. Achievability and Preparedness

The following questions and instructions were presented for consideration:

- Would students who achieve the tasks described in these standards be ultimately be prepared for success at college and/or in their careers? Support your answer with evidence.
- Are the tasks described in the performance expectations reasonable expectations for all students? (refer to The Next Generation Science Standards Appendix D: All Standards, All Students)

  To answer these questions, think about what students need to know and be able to do to be successful in life and also consider the time and effort needed to help all students achieve the stated expectations.

The following statements are a summary of the comments the Grades 9–12 subcommittee submitted by consensus:

Students who achieve the tasks described in these standards could ultimately be prepared for success in college and/or in a career. These standards provide the necessary content and skills required for that success.

As written without modifications, these high school standards are not reasonable expectations for all students. However, The Next Generation Science Standards Appendix D: All Standards, All Students provides detailed vignettes with videos of what these standards look like in six subpopulation classrooms (e.g., economically disadvantaged, race and ethnicity, students with disabilities, English language learners, girls, alternative education, and gifted and talented). In addition, with appropriate and thorough alignment of instructional materials and resources and the process of modifications for special needs students, most students could meet the minimum requirements.

E. Instructional Implications of the Standards

The following questions were presented for consideration:

- Do you think that these standards provide enough guidance to curriculum developers and educators to determine instructional sequences and instructional strategies? Why or why not?

The following statements are a summary of the comments the Grades 9–12 subcommittee submitted by consensus:

> These standards provide guidance to curriculum developers and educators to determine instructional sequences and instructional strategies. The document is open–ended enough and provides the minimal expectations for what students need to know and be able to do to give curriculum developers the freedom to develop and implement their own specific curriculum.

F. Scientific and Engineering Practices

The following questions were presented for consideration:

- Are the science and engineering practices represented with enough frequency in the grade band that students will have the opportunity to master the practice by the end of that grade band? Support your answer with evidence.

The following statements are a summary of the comments the Grades 9–12 subcommittee submitted by consensus:

> The eight science and engineering practices are represented with enough frequency in this grade band. Specifically, the Grade 8 and engineering practices are included a minimum of three times in the Grades 9–12 grade span. Modeling is especially emphasized.

G. Crosscutting Concepts

The following questions were presented for consideration:

- Are the crosscutting concepts represented with enough frequency so that students will understand them as crosscutting all the disciplines within science, and not relevant to just some areas of science (life science, earth science, physical science, engineering and technology)? Support your answer with evidence.
- Will the inclusion of these crosscutting concepts deepen the understanding of science and engineering concepts? Why or why not?

The following statements are a summary of the comments the Grades 9–12 subcommittee submitted by consensus:

> The seven crosscutting concepts are represented with enough frequency in this grade band. Specifically, the seven concepts are included a minimum of three times in the Grades 9–12 grade band. Crosscutting concepts make the science content more relevant and provide real world connections both within and across content areas.

H. Engineering Design

The following questions were presented for consideration:

- Will the inclusion of these engineering design standards deepen student understanding of science concepts? Why or why not?

The following statements are a summary of the comments the Grades 9–12 subcommittee submitted by consensus:

> The inclusion of these engineering design standards deepen student understanding of science concepts because of the practical applications of engineering in everyday life. The engineering standards actually take the students back to why scientists do science. The connection between engineering and science concepts in the engineering standards has the potential to deepen student understanding.

I. Connections

The following questions were presented for consideration:

- How will the inclusion of connections to the CCSS for ELA/Literacy affect instruction?
- How will the inclusion of connections to the CCSS for Math affect instruction?
- How will the connections to other disciplinary core ideas in this grade band affect instruction?
- How will the articulations of disciplinary core ideas across grade bands affect instruction?

The following statements are a summary of the comments the Grades 9–12 subcommittee submitted by consensus:

> The inclusion of the connections to the CCSS for ELA/Literacy can affect instruction positively. This supports students reading challenging content–based texts, writing argumentatively or informatively, and supporting their claims with text–dependent evidence.
>
> The inclusion of the connections to the CCSS for Math can affect instruction positively. Mathematical models, quantitative reasoning, graphing, and computational thinking are the language of science.
>
> The connections to other disciplinary core ideas in the high school band can affect instruction positively. The articulations of disciplinary core ideas across grade bands can affect instruction positively as well. Cross curricular collaboration is essential to meet the vision of the NGSS.

J. Utility

The following questions were presented for consideration:

- Please share your comments or concerns about the usability of the
    - online version of the NGSS overall;
    - sort by performance expectation function;
    - hyperlinks between and within the document;
    - PDF version by disciplinary core ideas;
    - PDF version by topic; and
    - the appendices.

The following statements are a summary of the comments the Grades 9–12 subcommittee submitted by consensus:

> Overall, the online version of the NGSS is teacher friendly and easy to navigate. The color coding feature is useful in illustrating the relationships between the performance expectations, and the science and engineering practices, disciplinary core ideas, and the crosscutting concepts from *A Framework for K–12 Science Education*. The online version is well-organized and is very detailed. There is ample information presented for teachers. The addition of clarification statements and assessment boundaries in the performance expectations are beneficial to planning instruction and assessment. Most users should be able to use the online version easily once they are trained. The color coding, pop–ups, and hyperlinks to *A Framework for K–12 Science Education* are very helpful.
>
> The sort by performance expectation function is teacher–friendly and very easy to use. Because the performance expectations are the focus of the NGSS, being able to sort by that function is an important and useful aspect. The performance expectation sort function allows users to sort by grade band/–level, science and engineering practice, crosscutting concept, and disciplinary core idea.
>
> Hyperlinks between and within the NGSS are quite helpful as the links provide more connections to the standards between all four content areas: physical science, life science, earth and space science, and engineering. The hyperlinks are abundant and useful in the online version of the NGSS standards. The ability to disable the pop–up dialog boxes when viewing the standards is a very helpful feature too.
>
> The PDF versions available when searching by disciplinary core idea and by topic are teacher–friendly and easy to use. Downloadable PDFs are always appreciated by teachers. The sort by topic function facilitates users in sorting the performance expectations commonly found in science courses already taught in Arkansas. The appendices provide examples, articles, case studies, references, and other information that are invaluable for teachers to understand these standards. Several of the appendices summarize the principles and background research of *A Framework for K–12 Science Education* and the CCSS. In addition, some appendices include concise tables that illustrate connections to the nature of science, the science and engineering practices, the crosscutting concepts, and learning progressions across grade bands. In particular, The Next Generation Science Standards Appendix D: All Standards, All Students and Appendix K:

Model Course Mapping in Middle and High School are valuable to curriculum developers and instructional facilitators to guide instruction in the classroom.