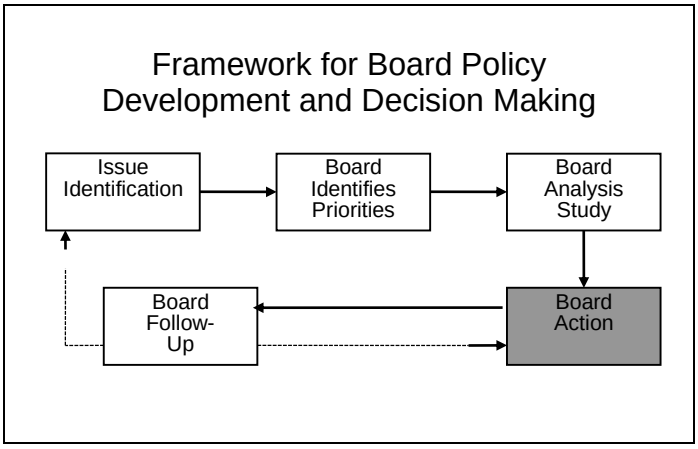
Iowa State Board of Education

Executive Summary

August 6, 2015



Agenda Item: Science Standards Review

Iowa Goal: All PK-12 students will achieve at a high level.

State Board Role/Authority The State Board has identified the Iowa Core as one of its priorities.

Presenter: Erika Cook, Chief
Bureau of Standards and Curriculum

Dave Tilly, Deputy Director
Division of Learning and Results

Mike Knedler, State Board Vice President

Hannah Rens, State Board Member

Attachments: 1

Recommendation: It is recommended that the State Board take action on the science standards recommendation from the Science Standards Review Team.

Background: This is a continuation of the conversation regarding the review of academic content standards in the area of science, per Governor Branstad's Executive Order 83 to engage in a transparent, regular review of state academic content standards. The report of the Science Standards Review Team will be provided. Review team recommendations for board positions and action on the standards will be provided. Opportunities for interaction around these topics will be provided throughout.

Science Standards

Review Team Report 2015

July 17, 2015

State of Iowa
Department of Education
Grimes State Office Building
400 E. 14th Street
Des Moines, IA 50319-0146

State Board of Education

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Introduction

Iowa's statewide academic standards set consistent expectations for what students should know and be able to do from kindergarten through high school in science, social studies, English-language arts, math and 21st century skills (civic literacy, employability skills, financial literacy, health literacy, and technology literacy). The standards, known as the Iowa Core, establish what students must learn to be prepared for success after high school. Local schools and educators continue to set and oversee decisions about curriculum and classroom instruction.

In October 2014, the Iowa Department of Education convened the Science Standards Review Team in response to Gov. Branstad's Executive Order 83. The executive order called for a review of Iowa's academic standards, including public comment, to determine the content of, and to continually improve, the standards. The science standards review will be followed by reviews of the other parts of Iowa's statewide standards.

Nineteen Iowans were named to the Science Standards Review Team, whose charge was to review Iowa's science standards, as well as rigorous science standards from other states and organizations; to take a preliminary recommendation to the public for feedback; and to consider the public feedback before sending a final recommendation to the Iowa Department of Education director and to the Iowa State Board of Education.

Team members included educators representing early childhood through higher education. The workforce representation included employees from agricultural, medical, aerospace engineering, and youth outreach programs. The voices on the review team represented a wide range of the state's population who have a stake in the science education of Iowa's youth.

This report culminates the efforts of the Science Standards Review Team for the express purpose of recommending a set of science standards for adoption by the State Board of Education.

Recommendations

After more than seven months of work and careful study, the Science Standards Review Team reached a recommendation for the State Board of Education through large and small group discussions, a thorough analysis of data from a public state survey and public forums, a review of science standards from other states, comparisons to the current Iowa Core standards, and clear, consistent voting procedures.

The Science Standards Review Team makes the following recommendations:

We recommend the Next Generation Science Standards performance expectations be adopted as Iowa's science standards, grade specific for grades K-8 and grade span for grades 9-12, acknowledging the importance of integrating the disciplinary core ideas, cross-cutting concepts, and science and engineering practices in achieving these standards. The performance expectations are statements of what students should be able to do to demonstrate their learning. They represent big ideas that combine content from the disciplinary core ideas, cross-cutting concepts, and science and engineering practices portions of the Next Generation Science Standards.

Additional recommendations are as follows:

- Professional development is provided to support the implementation of the new standards.
- Professional development resources are available for use by any providers, teacher leaders, and users.
- Time is provided for educators to take part in professional development.
- The Iowa Core website, IowaCore.gov, provides access to the corresponding supporting documents of the Next Generation Science Standards.
- The Assessment Task Force reconvenes as soon as the new science standards are approved and new assessments are available for review.

The Science Standards Review Team recognizes that, with the adoption of the above recommendations, Iowa's science standards will provide a guide to drive coherent, rigorous instruction that results in student mastery of scientific knowledge, reasoning, and skills. These standards focus on:

1. *Integration of disciplinary core ideas (DCIs) and science and engineering practices (SEPs)*
   The standards integrate disciplinary core ideas (concepts) with scientific and engineering practices (skills). The integration of rigorous concepts and practices reflects how science and engineering are applied and practiced every day.
2. *College and career readiness*
   The standards articulate key knowledge and skills students need to succeed in entry-level college or university courses as well as jobs or other post-secondary opportunities that require scientific and technical proficiency. The standards do not define advanced work in the sciences. The standards form a foundation for advanced work, but students wishing to move into STEM (science, technology, engineering, math) fields should be encouraged to follow their interest with additional coursework.
3. *Preparation of scientifically literate citizens*
   The integration of science and engineering practices, cross-cutting concepts, and disciplinary core ideas within each standard provides students with "the knowledge and skills required for personal decision making, participation in civic and cultural affairs, and economic productivity" (definition of science literacy from http://www.literacynet.org/science/scientificliteracy.html).

4. *Narrow breadth, deeper depth*
   The standards focus on a set of disciplinary core ideas that lead to deeper understanding and application of concepts. The standards are not intended to represent an exhaustive list of all that could be included in a student's science education, nor should they prevent students from going beyond the standards where appropriate.
5. *Coherent K-12 progression of concepts and practices*
   The standards emphasize a focused and coherent progression of knowledge and skills, allowing for a dynamic process of knowledge and skill building throughout a student's scientific education. The progression gives students the opportunity to re-conceptualize their understanding of how the natural and designed world works, leading to a sophisticated scientific and technical understanding.
6. *Disciplinary integration in grade-by-grade standards K through grade 8*
   To achieve consistency across schools and districts and to facilitate collaborative work, resource-sharing, and effective education for mobile populations, the K through grade 8 standards are presented by grade level. All four disciplines — earth and space science, life science, physical science, and technology/engineering — are included in each grade to encourage integration and the use of cross-cutting concepts and nature of science themes.
7. *Outcomes that allow for local control of curriculum*
   State science standards are outcomes, or goals, that reflect what a student should know and be able to do; they are not curriculum. They do not dictate the manner or methods by which the standards are taught. The standards are written in a way that expresses the concept and skills to be achieved and demonstrated by students, but leaves curricular and instructional decisions to districts, schools, and teachers. The standards are not a set of instructional activities or assessment tasks. They are statements of what students should be able to do as a result of instruction.

The following sections of the report and appendices provide evidence of the history and the processes used to reach the above recommendations.

Executive Order 83

Branstad signs Executive Order 83 to ensure local control in the development of Iowa Core standards and assessments
October 18, 2013

SECRETARY OF STATE (DES MOINES) – Gov. Terry E. Branstad yesterday signed Executive Order 83, ensuring local control in determining Iowa Core's state academic standards and assessments. The executive order reads as follows:

Executive Order Number Eighty-three
WHEREAS, the Iowa Constitution encourages a strong educational foundation by providing that, "[t]he General Assembly shall encourage, by all suitable means, the promotion of intellectual, scientific, moral, and agricultural improvement" (Iowa Const. art. IX, 2d, § 3); and

WHEREAS, rigorous state standards detailing expected academic achievement are essential to provide a high-quality education, which is key to students' futures and the future of this state; and

WHEREAS, the adoption of state standards should be done in an open, transparent way that includes opportunities for Iowans to review and offer input; and

WHEREAS, it is the responsibility of local school districts to make decisions related to curricula, instruction, and learning materials consistent with state academic standards; and

WHEREAS, it is inappropriate for the federal government to require as a condition of application of federal grants the adoption of any federally developed standards; and

WHEREAS, the protection of student and family privacy is paramount and Iowa must protect its citizens against intrusive, unnecessary data collection and tracking.

NOW, THEREFORE, I, Terry E. Branstad, Governor of the State of Iowa, declare the following:

The State of Iowa, not the federal government or any other organization, shall determine the content of Iowa's state academic standards, which are known as the Iowa Core. The Iowa Department of Education shall develop a regular review cycle for the Iowa Core, including public comment, to determine the contents of and to continually improve state academic standards.

The State of Iowa, not the federal government or any other organization, shall choose the statewide assessments that will measure how well students have mastered the Iowa Core. School districts may also choose to use additional assessments to measure student academic progress.

The collection of student data by school districts and the Iowa Department of Education shall be done in a manner consistent with state and federal laws intended to protect student and family privacy. Only aggregate student data shall be provided to the federal government to comply with federal laws.

No Constitutional right of Iowa children and their families shall be violated through an overreach by the federal government into Iowa's educational system.

IN TESTIMONY WHEREOF, I HAVE HEREUNTO SUBSCRIBED MY NAME AND CAUSED THE GREAT SEAL OF THE STATE OF IOWA TO BE AFFIXED. DONE AT DES MOINES THIS 16TH DAY OF OCTOBER IN THE YEAR OF OUR LORD TWO THOUSAND THIRTEEN.

_____
TERRY E. BRANSTAD
GOVERNOR OF IOWA
ATTEST:

_____
MATT SCHULTZ

Science Standards Review Team Membership

John Bedward: Assistant Professor of Education, STEM, Buena Vista University, Storm Lake

Lyn Countryman: Science Education Professor, University of Northern Iowa, Cedar Falls

Pam Elwood: Early Childhood Consultant, Green Hills Area Education Agency, Atlantic

Matthew Geraghty: Aerospace Engineering, Rockwell Collins, Cedar Rapids

Robin Habeger: Academic Outreach Manager, DuPont Pioneer, Des Moines

Renee Harmon: Science Learning, Science Center of Iowa, Des Moines

Kris Kilibarda: Director, Jacobson Institute, Grand View University, Des Moines

Rob Kleinow: Science Consultant, Heartland Area Education Agency, Johnston

Lisa Krapfl: Science Teacher, Holy Family Catholic Schools, Dubuque

Chris Kurtt: Science Teacher, Norwalk School District, Norwalk

Dean Lange: Engineering Teacher, Valley High School, West Des Moines Community School District

Jon Markus: 6th grade Earth and Space Science Teacher, Adel-DeSoto-Minburn Community School District

Ted Neal: Clinical Instructor Science Education, University of Iowa, Iowa City

Jim Pifer: Science Coordinator, Southeast Polk Community School District

Abby Richenberger: 8th Science Teacher, Edward Stone Middle School, Burlington Community School District

Ed Saehler: Environmental Education Coordinator, University of Iowa, Iowa City

Tamara Risen Trinder: Pediatric Nurse Practitioner, Mercy Clinics, Inc, Des Moines

Courtney Van Wyk: Middle School Science and STEM Teacher, Pella Christian Grade School, Pella

Wade Weber: Youth Development Program Specialist, Iowa State University Extension and Outreach, Ames

Facilitators

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Tina Wahlert: TS Educational Leadership Consultants, Anita, Iowa

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David Tilly, Iowa Department of Education, Des Moines

Phil Wise, Iowa Department of Education, Des Moines

Ryan Wise, Iowa Department of Education, Des Moines

Meeting Schedule

Science Standards Review Team Meetings

November 4, 2014	9:00 a.m. – 4:00 p.m.	Science Center of Iowa, Des Moines
December 4, 2014	9:00 a.m. – 4:00 p.m.	Science Center of Iowa, Des Moines
March 5, 2015	9:00 a.m. – 4:00 p.m.	Science Center of Iowa, Des Moines
March 24, 2015	9:00 a.m. – 4:00 p.m.	Science Center of Iowa, Des Moines
April 14, 2015	9:00 a.m. – 4:00 p.m.	Science Center of Iowa, Des Moines
May 7, 2015	9:00 a.m. – 4:00 p.m.	Science Center of Iowa, Des Moines
June 25, 2015	9:00 a.m. – 4:00 p.m.	Grimes State Office Building, Des Moines

Subcommittee Meeting

Life Science Team November 24, 2014	9:30 a.m. – 2:00 p.m.	DuPont Pioneer Johnston, Iowa
Middle School Science Standards Assignment June 3, 2015	9:00 a.m. – 4:00 p.m.	Lindquist Center Room 140 University of Iowa Iowa City, Iowa
June 4, 2015	9:00 a.m. – 4:00 p.m.	Lindquist Center Room 140 University of Iowa Iowa City, Iowa

Public Forums

February 11, 2015	4:30 p.m. – 6:30 p.m.	Waukee Community Schools District Office Waukee, Iowa
February 24, 2015	4:30 p.m. – 6:30 p.m.	Ottumwa AEA Ottumwa, Iowa
February 25, 2015	4:30 p.m. – 6:30 p.m.	Dubuque AEA Dubuque, Iowa
February 26, 2015	4:30 p.m. – 6:30 p.m.	NWAEA Building Sioux City, Iowa

Preliminary Work

The Science Standards Review Team was contacted through email prior to the first meeting of the group. The team was instructed to review the current Iowa Core science standards and the Final Evaluation of the Next Generation Science Standards (NGSS) by the Thomas B. Fordham Institute. Members were also told they would be looking at other states' and organizations' science standards and were given links to many of the sets of standards and asked to review them. The team was divided into content area groups to guide the work in examining state science standards: Physical Science, Life Science, Engineering, and Earth and Space.

Team Meeting One

November 4, 2014

The work of the Science Standards Review Team began in November of 2014 with a large group meeting and discussions about the charge to the team from Executive Order 83 regarding the review of Iowa's state academic standards. The team established meeting norms and a decision-making process.

Meeting Norms

Meeting participants and leaders will:

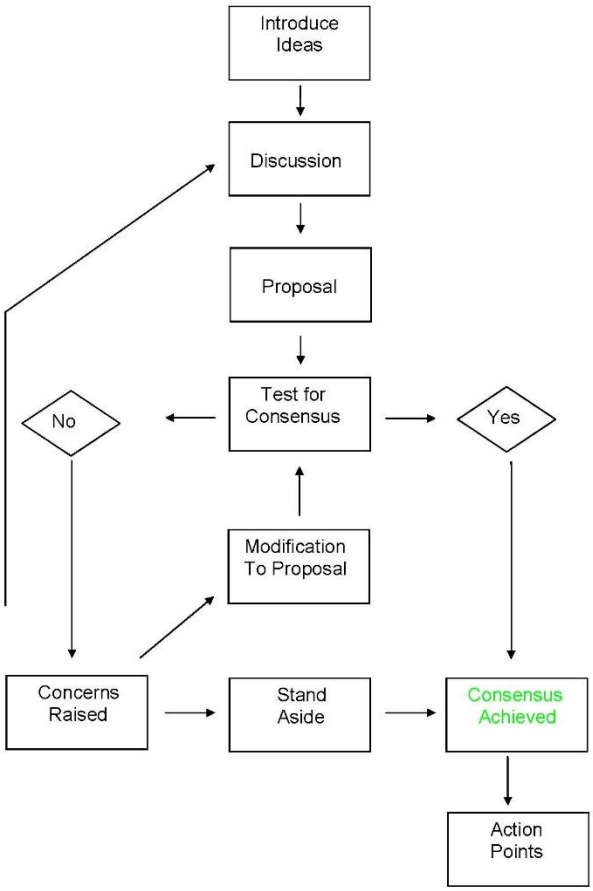
- **Treat everyone with respect**: We will express our opinions responsibly, focusing on the issues and not on personal differences, and speak both honestly and kindly. The rest of the norms are related to this one.
- **Prepare adequately for the meeting and participate fully:** We will have read, reviewed or examined pertinent documents, gathered information or input, or simply assessed our own thoughts and ideas prior to the meeting.
- **Engage each other's thoughts, ideas and opinions:** We recognize the value and richness of a meeting when everyone has a chance to participate. This norm also includes gracious acceptance of opinions different from our own.
- **Start and end meetings on time and arrive at meetings punctually:** We need to respect each other's time. The people who are present at the announced time should start without waiting for anyone not yet present.
- **Use technology wisely:** We recognize the value of our personal technology if it enhances the meeting experience for all, and the distraction caused by other types of personal technology. Choose wisely.

Decision-Making Process

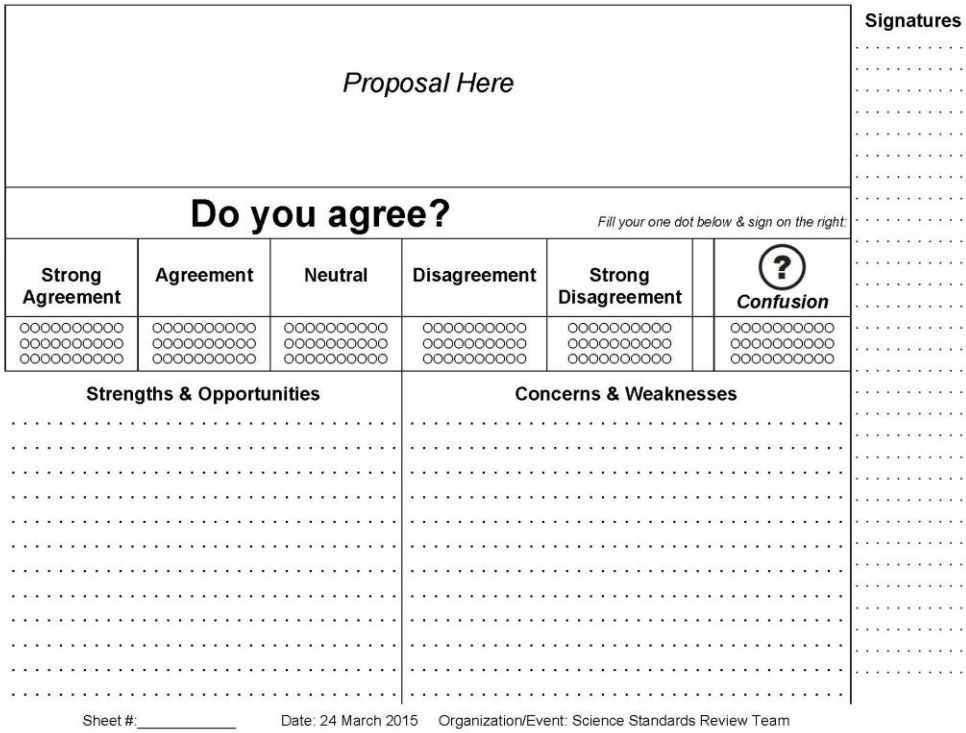
Each decision arising from an agenda item or emerging from group work follows a simple structure:

- **Discussion of the item:** The item is discussed with the goal of identifying opinions and information on the topic at hand. The general direction of the group and potential proposals for action are often identified during the discussion.
- **Formation of a proposal:** Based on the discussion, a formal decision proposal on the issue is presented to the group. There can be several proposals at a time put before the group, since any and every member of the team may make a submission.
- **Call for consensus:** The facilitator of the decision-making body calls for consensus on the proposal. Members of the group must actively indicate whether they agree or strongly agree, are neutral (stand aside), disagree or strongly disagree, or are confused by using a Proposal Rating Sheet. Members sign each sheet by filling in with a dot and may add brief comments regarding the strengths and opportunities, and concerns and weaknesses of the proposal. The result is a graph-like visual representation of the group's collective opinions on each idea.
- **Identification and addressing of concerns:** If consensus is not achieved, each dissenter presents his or her concerns on the proposal, potentially starting another round of discussion to address or clarify the concern.
- **Modification of the proposal:** The proposal is amended or re-phrased in an attempt to address the concerns of the decision-makers. The process then returns to the call for consensus and the cycle is repeated until a satisfactory decision passes the consent threshold for the group.
- **Additional vote:** If the group deems a single proposal on an issue does not clearly stand out as having the team's overwhelming consensus, a vote between various proposals will be conducted, with each team member voting for one of the proposals.
- **Yes or No vote:** Proposals can also be put before the group requesting a YES or NO vote by the team members.
- **Quorum:** As the meetings progressed, the group identified sixteen members as being active in attendance. The group agreed having nine members present at a meeting would constitute a quorum, and a majority vote would rule.

Decision-making Flowchart



Proposal Rating Sheet



Proposal Here

Do you agree? *Fill your one dot below & sign on the right:*

Strong Agreement	Agreement	Neutral	Disagreement	Strong Disagreement		? Confusion
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Strengths & Opportunities	Concerns & Weaknesses

Signatures

Sheet #:_____ Date: 24 March 2015 Organization/Event: Science Standards Review Team

Team Meeting One: Outcomes

November 4, 2014

Team members began by sharing their thoughts regarding the current Iowa Core science standards. Members identified what they perceived to be both the strengths of, and concerns with, the current standards.

A Proposal Rating Sheet was then used to determine if the members wished to keep the current Iowa Core science standards.

All team members disagreed with submitting the current Iowa Core Essential Concepts/Skills for Science as the recommendation for the State of Iowa K-12 Science Standards. Eleven members were in disagreement with this, and four members were in strong disagreement with this. Several members cited a concern of the current standards as being too vague.

Team members were then asked to suggest sets of science standards which they found to be worthy of a closer look. Iowa Core science standards, Next Generation Science Standards, Massachusetts, Ohio, 8 Plus 1, TIMSS, Oregon, and Washington were put before the group for examination with regard to content, process, performance expectations, and format.

Each of these sets of standards was then rated by all team members on a Proposal Rating Sheet. Team members rated their level of agreement with using each set of standards as a working document to modify into a document for the state of Iowa. Team members were in agreement that Oregon and Washington science standards were essentially the Next Generation Science Standards, so those two sets of standards were not rated by the group.

The team members agreed to study the Ohio and Next Generation Science Standards in greater depth, document the strengths and weaknesses of each, bring their findings to the December 4 meeting, and be prepared to make a final decision regarding the set of science standards to be chosen as a starting/working document for Iowa's science standards. Members were reminded to let the group know if they came across any other standards which they would like the group to study and consider at the December meeting.

See Appendix 1 for the Official Notes from the *4 November 2014 Meeting*

Team Meeting Two: Outcomes

December 4, 2014

On this meeting day, team members analyzed the Ohio State Science Standards and the Next Generation Science Standards. The group engaged in a discussion concerning the strengths and weaknesses of the two sets of standards with references to Iowa Core science. Content area groups reported out their views of each set, with strengths and weaknesses being identified.

After group discussion of the strengths and concerns, team members wrote proposals for consideration for the large group. Seven proposals were submitted for ranking using the Proposal Ratings Sheet. After all ratings were made, the committee recommended that the Next Generation Science Standards be sent for public opinion and feedback as the potential for Iowa's science standards.

The committee was informed that a survey would be developed and made available for the public to respond to the committee's vote and that public meetings would be held at four sites around the state. By the February meeting, the stakeholder survey data and public meeting data were to be organized and presented to this group. This meeting would allow the team members to determine if any modifications should be made to the Next Generation Science Standards before being submitted to the State Board of Education.

See Appendix 1 for the Official Notes from the *4 December 2014 Meeting*

Public Input and Data Collection

January 28--February 27, 2015

The public received multiple opportunities to provide input to the Science Standards Review Team. All team meetings were open to the public. Statewide media were notified in advance of meetings, and meeting reports and notes were posted on the Iowa Department of Education website, educateiowa.gov. In addition, Iowans were invited to provide input on the team's preliminary recommendation through four public forums across Iowa and through a statewide survey.

Public forums were held February 11 through February 26 in Waukee, Ottumwa, Dubuque, and Sioux City. Attendees who wished to speak signed in, gave their names, and had up to five minutes to offer opinions. Over 100 people attended the four meetings, with 43 electing to speak publicly. All meetings were recorded and made available to the Science Standards Review Team. In addition, a brief summary of the key points from each speaker was available for team evaluation.

The stakeholder survey was made public on January 28, 2015, and remained open until February 27, 2015. The survey was designed in two parts. There were 12 basic questions in Part 1 and comments could be given about the Next Generation Science Standards generally. Part 2 included more than 250 questions about disciplinary core ideas and sub-ideas with the ability to comment on each. The survey garnered 2,523 responses.

Iowans also contacted the Iowa Department of Education via email to offer opinions concerning state science standards. Emails were collected and given to the Science Standards Review Team to consider. One of the emails was a petition that included 307 signatures and a number of comments.

The team had access to all data in the original raw format, as well as spreadsheets that compiled the data by topic/concern. Each of the team's discipline area small groups addressed concerns raised by the public and supplied rationale for the team's actions. The process for analyzing the data and team considerations can be found in subsequent meeting notes and Appendix 3.

See Team Meetings Three and Five and Appendix 3 for details concerning how the data was addressed

Team Meeting Three: Outcomes

March 5, 2015

On this meeting day, team members were given the data from the public survey, four public forums, and the electronically submitted input received by the Iowa Department of Education. Members had an

opportunity to work in small groups according to content areas, individually, and also as a large group to analyze all data.

Through this data analysis, team members identified specific themes generated from the public feedback, and reported those items to the large group. These items were then addressed by the group according to themes from the survey, public forums, and electronic submissions and/or items tied to specific survey questions.

Team members were instructed to continue their review of the feedback, reflect on the specific themes that emerged from public input, and be prepared to address each item when they came to the next meeting.

See Appendix 1 for the Official Notes from the 5 March 2015 Meeting

Team Meeting Four: Outcomes

March 24, 2015

Team members were ready to decide if the Next Generation Science Standards would be the starting point for their work and a Proposal Rating Sheet was used for the following proposal:

Proposal: The Next Generation Science Standards should be the starting point to develop a document to be submitted as the recommendation for the State of Iowa K-12 Science Standards. Nine members were in strong agreement or agreement with this proposal, with one member in disagreement.

The team agreed to move forward with the acceptance of the Next Generation Science Standards as its starting point.

The team recognized the need to define “standard” when referring to the Next Generation Science Standards. The large group discussed this at length, making references to the authors’ intent, public feedback data, and professional experience with the Next Generation Science Standards. Two proposals were put before the group:

Proposal One: Our recommendation is that the NGSS performance expectations that include the science and engineering practices, disciplinary core ideas, and cross-cutting themes are adopted as the Iowa Core Science Standards. (Note: the Performance Expectation appears as the standard on the website and links to the foundation boxes.) Eight members were in strong agreement or agreement with this, and three members were in disagreement.

Proposal Two: The NGSS performance expectations are the Iowa Core Science Standards. Nine members were in agreement with this, one member was in disagreement, and one member was neutral.

The team did not feel there was overwhelming agreement on either of the proposals. The first proposal had more members in strong agreement, but there were three members who disagreed. Only one member disagreed with the second proposal, but no members were in strong agreement with it. More discussion ensued, and the following proposal was written for the large group to consider. Note: This proposal was with regard to the Next Generation Science Standards as a *starting point* for a recommendation yet to be made.

Proposal: The Iowa Core Science Standards are the NGSS Performance Expectations which are constructed from the three foundation boxes. Ten members were in strong agreement or agreement with this, and one member was in disagreement.

Team members agreed they would consider standards to be the performance expectations which are constructed from the three foundation boxes, as they moved forward with their work. The team members continued reviewing the themes that emerged from their analysis of the public feedback data.

After content area group work and large group work addressing topics that members had identified as needing more discussion based upon the public feedback data, the team's discussion centered upon whether the middle school standards should be grouped together or individually by grades 6, 7 and 8. The following question was put before the large group to consider:

Question: How should Iowa approach the Middle School Standards? Six members voted to keep them together in a single middle school grade band, and four members voted to assign specific standards to Grade 6, Grade 7, and Grade 8.

Recognizing the importance of this issue, and taking into consideration the public feedback on this issue, the team debated this at length and worked together to develop the following proposal for the large group to consider. Note: This proposal was with regard to the Next Generation Science Standards as a *starting point* for a recommendation yet to be made.

Proposal: Middle schools should adopt an integrated sequence with specific Performance Expectations located in grades 6, 7, and 8 as per the conceptual progressions pathway in Appendix K of the NGSS. Ten members were in strong agreement or agreement with this, and one member was in disagreement.

The Science Standards Review Team agreed at the next meeting it would go over the Next Generation Science Standards in detail and consider any further adaptations based on public feedback.

See Appendix 1 for the Official Notes from the 24 March 2015 Meeting

Team Meeting Five: Outcomes

April 14, 2015

Team members reconvened to engage in more in-depth discussion on the topics identified from the public comment data, in relation to the Next Generation Science Standards, during Team Meeting 4. The team divided these issues/topics among the content area groups for each group to examine in more depth, based on their areas of expertise and the focus of the issue/topic.

The content area groups used worksheets designed to 1) identify the issue or concern, 2) identify the Next Generation Science Standards that address the issue or concern, 3) reference the public feedback data points which relate to the issue or concern and 4) make a recommendation for any adaptations of the Next Generation Science Standards based upon the public feedback.

The following issues/concerns were examined and documented:

1. Weather and climate.
2. Human impacts on Earth systems.
3. Global climate change.
4. Earth and human activity.

5. The words "over the past century" in the standard MS-ESS 3-5 "*Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.*"
6. Science teachers are uncomfortable teaching engineering design practices.
7. Where should health/wellness/human body systems/nutrition be addressed?
8. Should biological evolution be the only theory utilized in the Next Generation Science Standards?
9. Whether middle school standards should be assigned to a grade span or a grade level.
10. Whether middle school standards should be integrated or discipline specific.
11. One common criticism of the Next Generation Science Standards is that the organization of the Next Generation Science Standards is not user-friendly.
12. Next Generation Science Standards content is too dense (particularly at the high school level).
13. It is important to ensure that Iowa adopt standards that will prepare graduates to be college and career ready.
14. Executive Order "...WHEREAS, rigorous state standards detailing expected academic achievement are essential to provide a high-quality education, which is key to students' futures and the future of this state..."

Each of the fourteen identified issues/concerns were then discussed as a reconvened large group. All review team members had an opportunity to offer input for clarification, additions, and modifications to content area group work.

The whole review team made decisions for each of the fourteen issues/concerns identified from public comment and feedback data. The review team developed rationale for each of the decisions, based on the public comment and review team expertise and experience.

The team synthesized the decisions, discussed and crafted a proposed recommendation. Following a simple yes or no vote, the committee voted on the following recommendation:

> *We recommend the Next Generation Science Standards performance expectations be adopted as grade specific for grades K-8 and grade span 9-12 as Iowa's State Science Standards.*

Nine members voted yes for this recommendation, and two members voted no.

The recommendation was to be formalized in a report to be submitted to the State Board of Education, documenting the work of the Science Standards Review Team. The facilitators were to work with team members to construct a rough draft of a report for the team to review prior to its next meeting.

See Appendix 1 for the Official Notes from the 14 April 2015 Meeting

See Appendix 3 for the Issues/Concerns documentation

Team Meeting Six: Outcomes

May 7, 2015

The group discussed a potential issue of Next Generation Science Standards being introduced at grade levels before the needed math skills are introduced according to the Iowa Core math standards. Another issue was raised concerning the number of standards introduced at each grade level. The team agreed to vote once again to recommend whether the Iowa science standards should be 6, 7 and 8 grade-specific, or a 6-8 grade span.

Eight members voted for grade-specific standards and eight members voted for a 6-8 grade span.

With the team members evenly split on this issue, discussion continued with each team member individually expressing his/her viewpoint on the issue of grade span versus grade-specific 6, 7 and 8 standards. After all arguments were heard, the team once again voted to determine if the Iowa science standards should be 6, 7 and 8 grade-specific, or 6-8 grade span.

Twelve members voted for 6, 7, and 8 grade-specific and 4 voted for 6-8 grade span.

It was determined that the team would continue with its recommendation for grade-specific standards for grades 6, 7 and 8. Team members then decided if they should as a large group begin the work of assigning standards to grades 6, 7 and 8, or if they should create a subcommittee to begin the work.

The vote was 12-4 for the subcommittee to begin the work of deciding upon grades 6, 7, and 8 content.

After discussing the recommendation decided upon at the April 14th meeting, the team agreed that clarification was needed for the recommendation to the State Board of Education to accurately reflect the intent of the group. With a show of hands, team members were unanimous in deciding the official recommendation to be:

> ***We recommend the Next Generation Science Standards Performance Expectations be adopted as Iowa's Science Standards, grade specific for grades K-8 and grade span for grades 9-12, acknowledging the importance of integrating the Disciplinary Core Ideas, Cross-cutting Concepts, and Science & Engineering Practices in achieving these standards.***

Team members discussed additional recommendations that were brought to their attention from the report-writing subcommittee that met after the April 14 meeting. The team agreed to include the following items in its final report, with the understanding that these recommendations would be reviewed in the next draft of the report by the entire group.

It is also recommended that:

- *Professional development is provided to support the implementation of the new standards.*
- *Professional development resources are available for use by any providers, teacher leaders, and users.*
- *Time is provided for educators to take part in professional development.*
- *The Iowa Core website provides access to the corresponding supporting documents of the Next Generation Science Standards.*
- *The Assessment Task Force reconvenes as soon as the new science standards are approved and new assessments are available for review.*

The recommendations were to be formalized in a report to be submitted to the State Board of Education, documenting the work of the Science Standards Review Team. A subcommittee was to designate grade-specific standards for grades 6, 7 and 8 to recommend to the team. The facilitators were to work with members of the team to construct the report for the team to review prior to the June 25 meeting. At this meeting, the report was to be finalized and officially approved by the Science Standards Review Team.

See Appendix 1 for the Official Notes from the 7 May 2015 Meeting

Subcommittee Work: Outcomes
June 3-4, 2015

See Appendix 2 for the Science Subcommittee Report

Team Meeting Seven: Outcomes

June 25, 2015

The team members convened on this day prepared to discuss the work of the subcommittee 6-8 science standards assignment work, and to offer input for clarification, additions, and modifications of the draft of the final report to be presented to the State Board of Education.

The work of the subcommittee was shared with the team, and the Science Standards Review Team expressed its satisfaction with the process and results of the 6-8 science standards assignments.

Team members then reviewed each section of the final report draft, making some minor word changes. Once the editing of the report was done, the team felt it reflected the decisions that had been made by the team throughout the standards review process, that it was accurate in content, and it accurately summarized the work of the team. Members then voted on the following:

This report reflects the work, decisions and recommendations of the Science Standards Review Team. To what extent do you approve this report being sent to the Iowa State Board of Education?

The vote was 13-0 for approval of the final report to be sent to the State Board of Education.

See Appendix 1 for the Official Notes from the 25 June 2015 Meeting

Appendix 1: Meeting Notes

November 4, 2014

https://www.educateiowa.gov/sites/files/ed/documents/2014-11-04ICScienceStandardsReviewTeamMeetingNotes.pdf

December 4, 2014

https://www.educateiowa.gov/sites/files/ed/documents/2014-12-04ICScienceStandardsReviewTeamMeetingNotes.pdf

March 5, 2015

https://www.educateiowa.gov/sites/files/ed/documents/2015-03-05ICScienceStandardsReviewTeamMeetingNotes.pdf

March 24, 2015

https://www.educateiowa.gov/sites/files/ed/documents/2015-03-24ICScienceStandardsReviewTeamMeetingNotes.pdf

April 14, 2015

https://www.educateiowa.gov/sites/files/ed/documents/2015-04-14ICScienceStandardsReviewTeamMeetingNotes.pdf

May 7, 2015

https://www.educateiowa.gov/sites/files/ed/documents/2015-05-07ICScienceStandardsReviewTeamMeetingNotes.pdf

June 25, 2015

https://www.educateiowa.gov/sites/files/ed/documents/2015-06-25ScienceStandardsReviewTeamMeetingNotes.pdf

Appendix 2: Science Grades 6-8 Subcommittee Report

SCIENCE GRADES 6-8 SUBCOMMITTEE REPORT

3 June 2015 and 4 June 2015

Teacher Leader Center
140N Lindquist Hall
240 S Madison Street
Iowa City, Iowa 52242

Subcommittee Members:

Lisa Krapfl, 6th Grade Science Teacher, Holy Family Catholic Schools
Jon Markus, 6th Grade Science Teacher, Adel-DeSoto-Minburn Middle School
Ted Neal, Clinical Instructor, Science Education, University of Iowa
James Pifer, Science Curriculum Coordinator, Southeast Polk Schools
Tami Plein, Science Specialist, Great Prairie AEA
Abby Richenberger, 8th Grade Science Teacher, Edward Stone Middle School

Our Process:

We, the science grades 6-8 subcommittee, began the day with an informal discussion of the previous day's conversation with Teresa Eliopaulos from Achieve. We began the official work by defining what our work/goal would be for the day:

Goal: Assign the NGSS Science Standards (Performance Expectations) to Grades 6, 7 and 8.

We offered ideas of things we felt needed to be addressed:

1. Math alignment
2. Repeats/duplicates
3. Topical Connections of Performance Expectations (PEs)
4. With regard to Physical Science, what is fundamental to know in order to learn the other content areas of life and earth science?

We began formulating our rules and guidelines for the day:

1. Standards within each grade level must come from each scientific discipline in order to integrate.
2. Standards had to be within a conceptual progression from foundation knowledge and skills to advance knowledge and skill application for their respective grade levels.
3. Alignment with needed math skills had to be taken into consideration, looking at Connection Boxes in the NGSS.

Standards were printed on color-coded pieces of paper. We decided to start by laying out the standards according to California's middle school model, because to our knowledge, they were the most recent and integrated.

Once laid out, we realized we did not agree with several aspects of California's middle school model. Much of the reasoning came from the heavy load and higher-level PE's in 6th grade. We then began the task of creating the "Iowa Model."

The "Iowa Model" began with members placing physical science PEs for each grade level. Physical science was placed first because of the concept of energy being essential as foundational knowledge to continue learning life and earth science concepts. After finding a conceptual progression from sixth-through-eighth grade in physical science, we moved on to earth and life science. These PEs were placed for interrelatedness to the concepts in the grade level as well as increasing complexity through 8th grade. The Engineering, Technology, and Applications of Science PE's were assigned to each grade level. After placing every PE, we compared our PE placements to the NGSS Foundation boxes for balance in grade levels, science and engineering practices, cross-cutting concepts, math level, and Bloom's Revised Taxonomy. This process of checking for balance helped us make additional moves of PE's.

Table 1-1

Number of Performance Expectations per Grade Level		
6th Grade	**7th Grade**	**8th Grade**
19	23	25

Graph 1-1

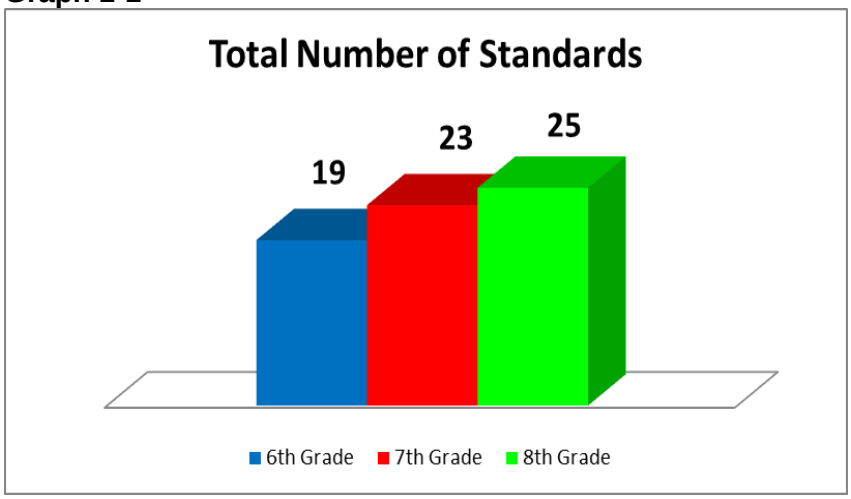


Table 1-2

Science and Engineering Practices Balance			
Practice	**6th Grade**	**7th Grade**	**8th Grade**
1 - Asking Questions and Defining Problems	0	1	1
2 - Developing and Using Models	6	6	3
3 - Planning and Carrying Out Investigations	1	2	2
4 - Analyzing and Interpreting Data	3	2	3
5 - Using Mathematics and Computational Thinking	0	0	2
6 - Constructing Explanations	3	4	6
7 - Engaging in Argument from Evidence	1	4	2
8 - Obtaining, Evaluating, and Communicating Information	1	0	2

Graph 1-2

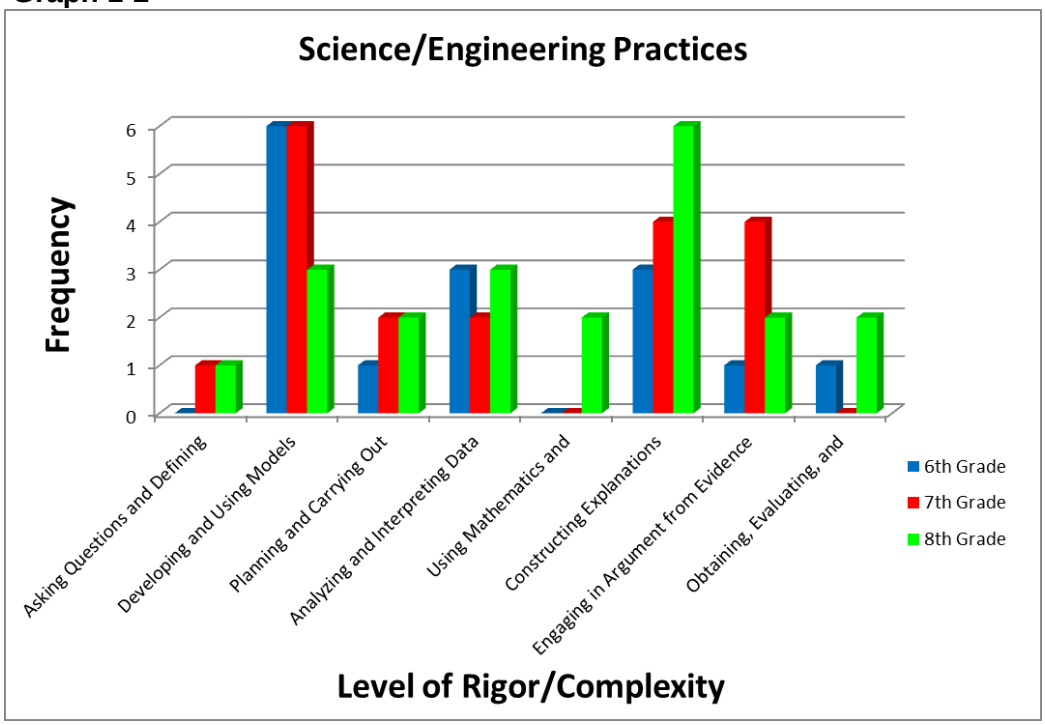


Table 1-3

Cross-cutting Concepts Balance			
Concept	**6th Grade**	**7th Grade**	**8th Grade**
1 - Patterns	3	2	4
2 - Cause and Effect	4	5	6
3 - Scale, Proportion, and Quantity	3	3	1
4 - Systems and Systems Models	1	3	2
5 - Energy and Matter	2	4	2
6 - Structure and Function	2	1	2
7 - Stability & Change	1	1	3

Graph 1-3

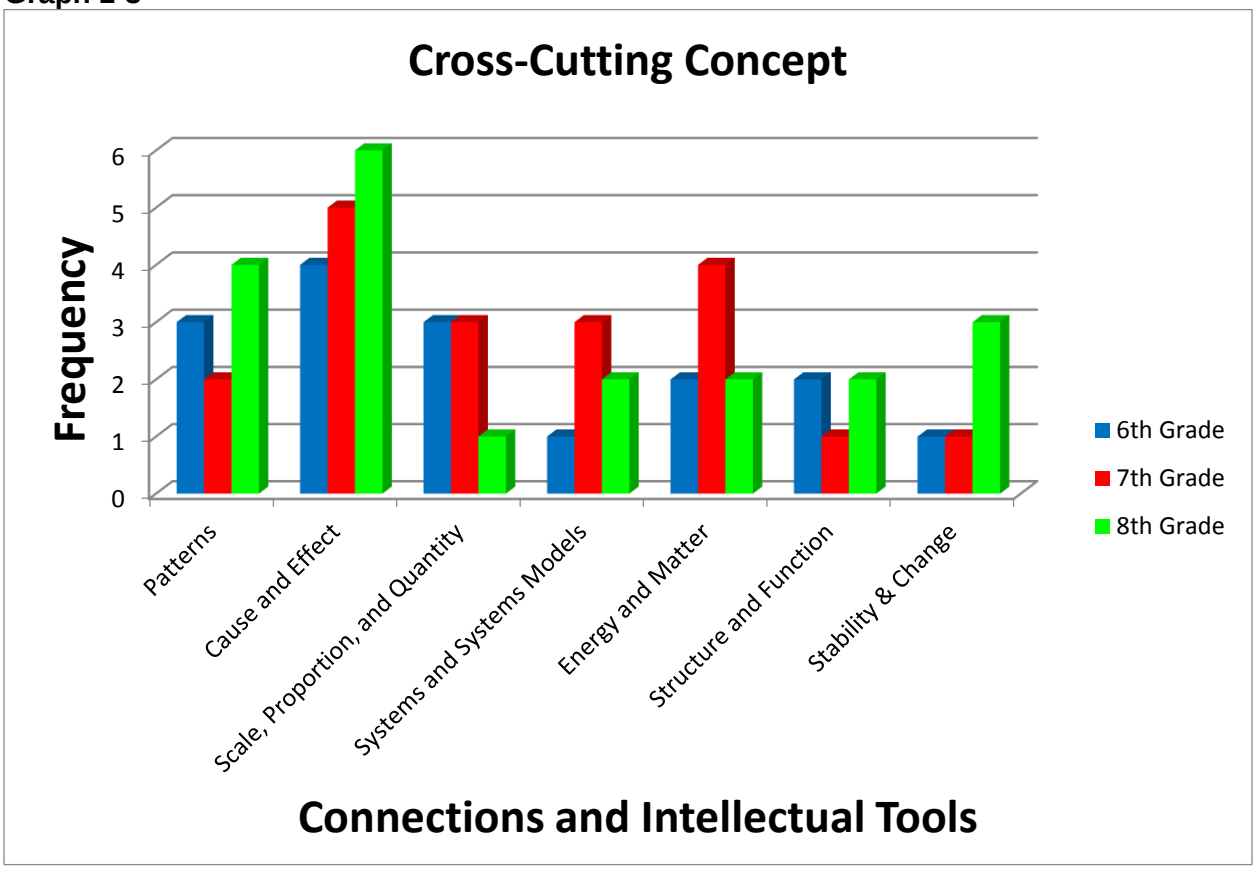


Table 1-4

Bloom's Revised Taxonomy in Each Grade Level			
Level of Thinking	**6th Grade**	**7th Grade**	**8th Grade**
Creating	1	1	2
Evaluating	1	5	3
Analysing	4	5	4
Applying	1	0	3
Understanding	8	8	9
Remembering	0	0	0

Graph 1-4

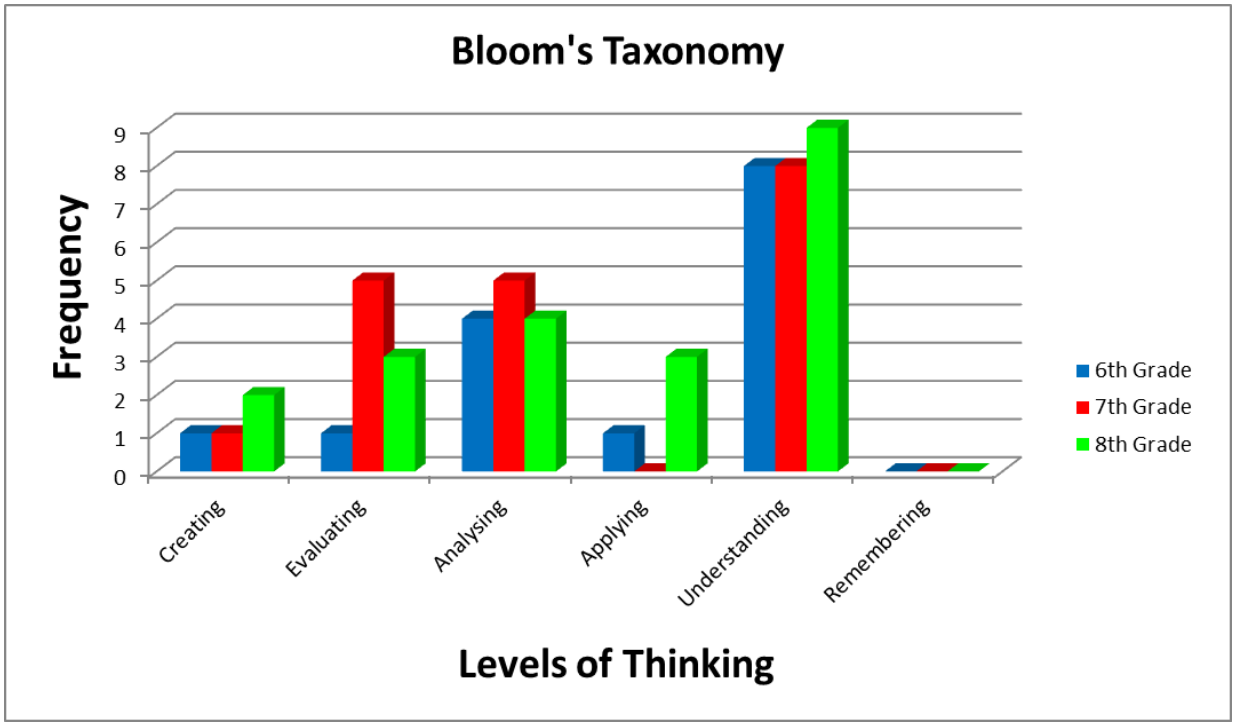


Table 1-5

6th Grade - Core and Component Ideas From Framework
PS1 Matter and Its Interactions
ESS2 Earth's Systems ESS3 Earth and Human Activity
LS1 From Molecules to Organisms: Structures and Processes LS3 Heredity: Inheritance and Variation of Traits
ETS1: Engineering Design ETS2: Links Among Engineering, Technology, Science, and Society

Table 1-6

7th Grade - Core and Component Ideas From Framework
PS2 Motions and Stability: Forces and Interactions PS3 Energy
ESS1 Earth's Place in the Universe
LS1 From Molecules to Organisms: Structures and Processes LS2 Ecosystems: Interactions, Energy, and Dynamics LS3 Heredity: Inheritance and Variation of Traits
ETS1: Engineering Design ETS2: Links Among Engineering, Technology, Science, and Society

Table 1-7

8th Grade - Core and Component Ideas From Framework
PS1 Matter and Its Interactions PS2 Motion and Stability: Forces and Interactions PS3 Energy PS4 Waves and Their Applications in Technologies for Information Transfer
ESS2 Earth's Systems ESS3 Earth and Human Activity
LS2 Ecosystems: Interactions, Energy, and Dynamics LS4 Biological Evolution: Unity and Diversity
ETS1: Engineering Design ETS2: Links Among Engineering, Technology, Science, and Society

Iowa Core Science Standards - Grades 6-8:

Table 2-1

Performance Expectations in Grade Levels			
Discipline	**6th Grade**	**7th Grade**	**8th Grade**
Physical Sciences	MS-PS1-1	MS-PS2-3	MS-PS1-3
	MS-PS1-2	MS-PS2-4	MS-PS2-1
	MS-PS1-4	MS-PS2-5	MS-PS2-2
	MS-PS1-5	MS-PS3-2	MS-PS3-1
	MS-PS1-6	MS-PS3-4	MS-PS3-3
		MS-PS3-5	MS-PS4-1
			MS-PS4-2
			MS-PS4-3
Earth & Space Sciences	MS-ESS2-1	MS-ESS1-1	MS-ESS2-4
	MS-ESS2-2	MS-ESS1-2	MS-ESS2-5
	MS-ESS2-3	MS-ESS1-3	MS-ESS2-6
	MS-ESS3-1	MS-ESS1-4	MS-ESS3-3
	MS-ESS3-2		MS-ESS3-4
			MS-ESS3-5
Life Sciences	MS-LS1-1	MS-LS1-4	MS-LS2-5
	MS-LS1-2	MS-LS1-5	MS-LS4-1
	MS-LS1-3	MS-LS1-6	MS-LS4-2
	MS-LS1-8	MS-LS1-7	MS-LS4-3
	MS-LS3-2	MS-LS2-1	MS-LS4-4
		MS-LS2-2	MS-LS4-5
		MS-LS2-3	MS-LS4-6
		MS-LS2-4	
		MS-LS3-1	
Engineering, Technology, and Applications of Science	MS-ETS1-1	MS-ETS1-1	MS-ETS1-1
	MS-ETS1-2	MS-ETS1-2	MS-ETS1-2
	MS-ETS1-3	MS-ETS1-3	MS-ETS1-3
	MS-ETS1-4	MS-ETS1-4	MS-ETS1-4

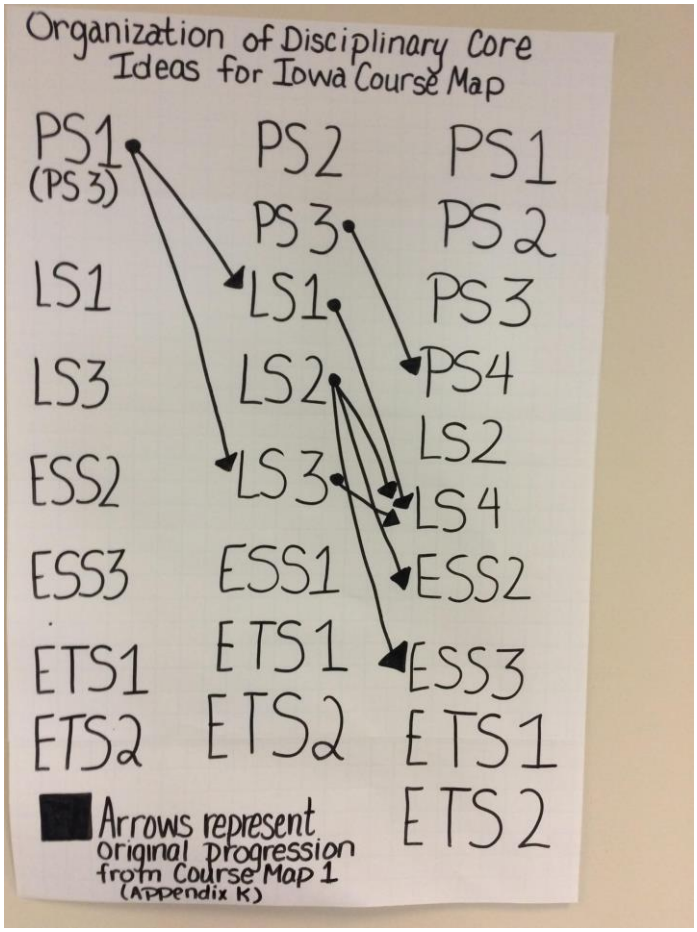
Next Steps:

Our recommendation is that all grade levels start with Physical Science. Physics First, an educational program that began in the early 90's, suggests that the fundamental ideas in physics underlie all the processes seen in the life sciences and earth sciences. The flow of matter and energy as a system is the most crucial understanding of the geoscience processes in earth science and the interactions of ecosystems.

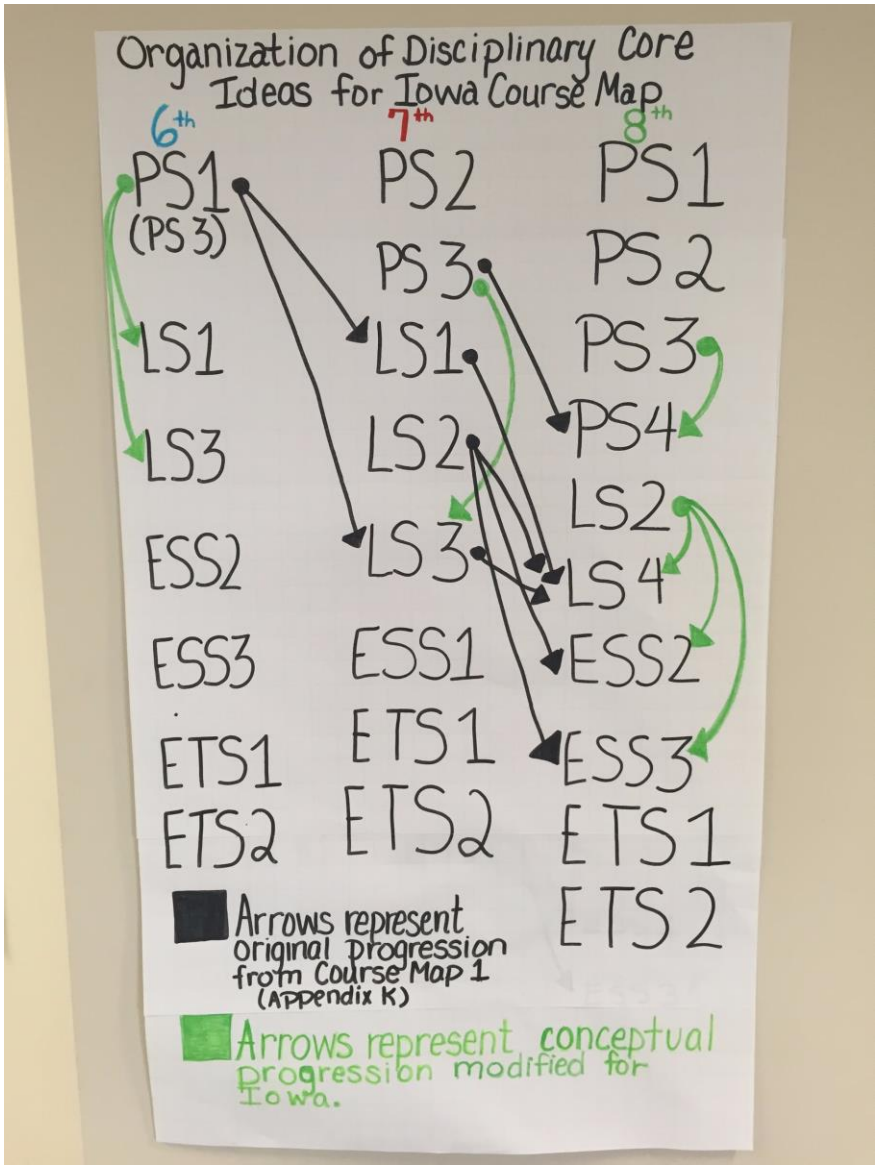
To that end, our second recommendation is that 8th grade ends with an Earth science unit as a capstone experience. The complexity and often controversial concept of climate change can only be fully understood with a comprehensive understanding of physical, life, and earth sciences. "Student understanding of climate systems requires preexisting understandings in biology, chemistry, and physics."[1]

We would also like to point out that the Engineering, Technology, and Applications of Science PEs are listed in 6th, 7th, and 8th grades. We recommend that these are integrated within a concept(s). It is suggested "…learning about science and engineering involves integration of the knowledge of scientific explanations (i.e., content knowledge) and the practices needed to engage in scientific inquiry and engineering design. Thus... knowledge and practice must be **intertwined** in designing learning experiences in K–12 science education."[2] We are emphatic that Engineering, Technology, and Applications of Science PEs are NOT taught in isolation as a nature of science unit, but rather as solving a scientific problem in earth, life, or physical sciences.

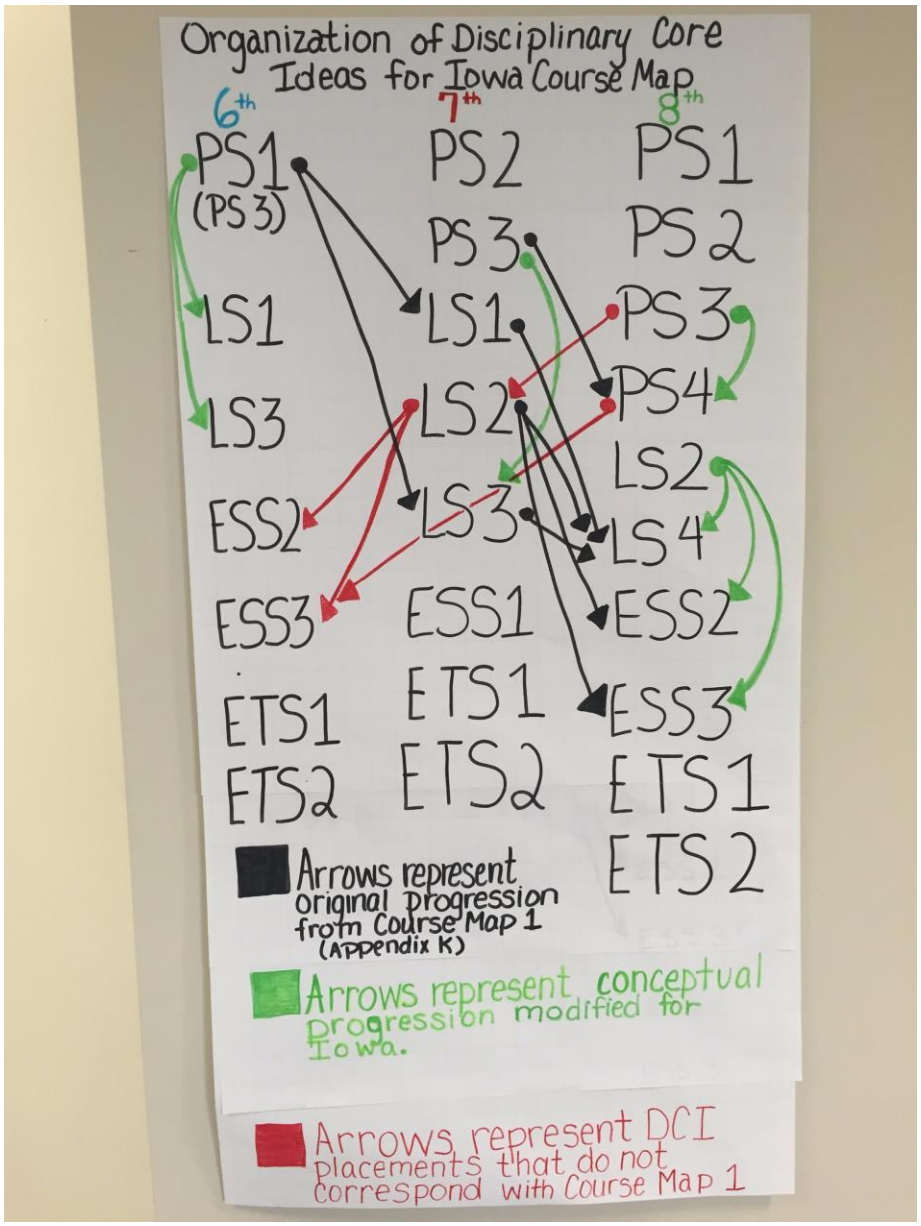
Grade level performance expectations can be organized by content or by cross cutting theme clusters in ways that create connections in student learning.



This Iowa Organization of Disciplinary Core Ideas Course Map (above) is intended to help visualize the flow of foundational concepts so that the component ideas of the Disciplinary Core Ideas (DCIs) progressively build the skills and knowledge described. DCIs do contain content that can be logically sequenced. Creating a logical sequence for the DCI portion of the performance expectations for this model was a multi-stage effort by the writers at Achieve that relied heavily on the Framework. The black arrows are from Course Map 1 in Appendix K, which was the original choice of the Work Group for the 6-8 progression.



The green arrows (above) represent the conceptual progression as modified for Iowa. They provide opportunities for continuing the flow of foundational concepts within a grade level. They also provide more flexibility for local districts to make explicit cross-cutting concept connections between the disciplines.



The red arrows represent DCI placements that don't correspond with Course Map 1 in Appendix K. Rationale for these placements are:

1) Placement of PS1 in 6th & 8th grade: Iowa Science Standard MS-PS 1-3 (*Gather and make sense of information to describe that synthetic materials come from natural resources and impact society*) was placed in 8th grade because it created a learning progression of the DCIs across the grade levels. The DCIs associated with this standard were not considered to be foundational to other standards in the previous grades. It also provided a better balance of Cross-Cutting Concepts for this grade span.
2) Placement of PS3 in 8th vs. 7th grade: Iowa Science Standard MS-PS 3-1 (*Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.*) was moved to 8th grade to meet the guideline for aligning math skills found in the NGSS Connections box with Iowa Core Math Standards for that grade level. MS-PS3-3 (*Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer*) was placed in 8th grade because it created a learning progression of the DCIs across the grade levels. The DCIs associated with

this standard were not considered to be foundational to other standards in the previous grades. It also provided a better balance of Cross-Cutting Concepts for this grade span.

3) Placement of PS4 in 8th grade: All 4 Standards in this DCI were left together as a group. The energy concepts in this DCI are not foundational concepts for ESS3 in 6th grade.
4) Placement of ESS2 in 6th grade: MS-ESS-2-1 (*Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process*), MS-ESS2-2 (*Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales*), and MS-ESS2-3 (*Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions*) are only three of the standards from this DCI moved to this grade level. The life science DCIs in LS2 are not considered foundational concepts for ESS2 in 6th grade. These were moved to 6th grade to meet our first guideline of integration.
5) Placement of ESS3 in 6th grade: MS-ESS3-1 (*Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes*) and MS-ESS3-2 (*Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects*) are only three of the standards from this DCI moved to this grade level. The concepts in LS2 and PS4 are not considered foundational for ESS3 standards placed in 6th grade. These were moved to 6th grade to meet the guideline of integration.

Final Words

We, the subcommittee, completed our work on assigning the NGSS Science Standards Performance Expectations to grades 6, 7 and 8. Together, we offer leadership as practicing middle school teachers, AEA educators, and university educators. We strongly believe that we have considered the placement of the standards from every facet or angle as suggested by NGSS Appendix K. Our work session as a sub-group, along with the valuable discussions with the larger Science Standards Review Team, provided the Iowa perspective that formed the guidelines that were used to determine the placement of standards in grades 6-8.

Works Cited:

1 Wysession, Michael E. "The Next Generation Science Standards and the Earth and Space Sciences." NSTA's Science Scope. (2013). 5-6.

2 "A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas." The National Academies Press. Washington, DC. (2011). 11. Retrieved from http://www.nap.edu/catalog.php?record_id=13165

Documents Referenced:

California 6-8 Standards

Appendix D, F, G, K of NGSS Revised and Modified

NSTA Quick-Reference Guide to the NGSS Middle School

Iowa Core Math Standards

Atlas of Science Literacy

Making Sense of Secondary Science

A Framework for K-12 Science Education

Revised Bloom's Taxonomy

Appendix 3: Summary of Data-Based Decisions

Recommendations based on the identified issues from the feedback or as specified in Executive Order 83.

Issue or Concern Addressed:
One common criticism of the Next Generation Science Standards is that the organization of the NGSS is not user-friendly.

Recommendation:
The team is recommending the adoption of the Next Generation Science Standards performance expectations as the Iowa Core Science Standards.

A. Further clarification of recommendation

B. Referring to data/feedback/comments

On the survey 63% of the entire group of respondents indicated they strongly agree or agree that the NGSS are "well-organized and easy to read" so it appears the majority of Iowans do not have concerns about the organization. However, a group of respondents (169 people: 7% of total respondents) who self-identify as being directly involved in science education indicated they disagree or strongly disagreed with the statement that the NGSS "are well-organized and easy to read." Of this group, respondents commented that the entire page was overwhelming and that it was difficult to identify the actual "standard." Some felt the assessment boundaries unreasonably limited teaching and learning and others were concerned that linking a particular science/engineering practice with a particular concept was limiting. The team recognized these concerns and understood the need to make the standards clear and concise. Many comments from the survey and from the various forums stressed the importance of students learning how to accomplish the work of scientists. Some of the forum comments also focused on making sure the standards were in line with the governor's STEM initiative. The team supports this reasoning and believes the Next Generation performance expectations provide a clear description that includes science and engineering practices, content (disciplinary core ideas), and cross-cutting themes.

C. Additional recommendations
Assessment boundaries and connection boxes could be available as districts implement the standards but would not be required. The team also recognizes the possibility that linking a practice with a concept could limit teaching and learning and that teachers and administrators will need quality professional development to ensure effective implementation.

Recommendations based on the identified issues from the feedback or as specified in Executive Order 83.

Issue or Concern Addressed:

NGSS content is too dense (particularly at the high school level).

Recommendation:

The team recommends adopting the NGSS performance standards as written in the NGSS document.

A. Further clarification of recommendation

B. Referring to data/feedback/comments

The majority of respondents indicated agreement with the standards leaving the wording as is. The most common suggestion for changing specific wording or elimination of the standard was related to the Nuclear Processes. In reviewing the comments, many of the concerns were related to the depth of material within the disciplinary core idea foundation boxes, the assessment boundaries and clarification statements. The team's recommendation of using the NGSS performance expectations as the standards will address these issues.

C. Additional recommendations

The supplemental materials may be available for teachers, administrators, and consultants to use as guidance but will not be mandated. This will allow for local control and for individual teachers to make instructional decisions.

Recommendations based on the identified issues from the feedback or as specified in Executive Order 83.

Issue or Concern Addressed:
Whether middle school standards should be assigned to a grade span or a grade level?
Whether middle school standards should be integrated or discipline specific?

Recommendation:

Using TABLE One *Conceptual progression model course map*, p.11 Appendix K. We recommend that the NGSS middle school standards are grade level specific and have integrated disciplines.

The grade banded PEs are organized so that student understanding of concepts is built progressively throughout the course sequence. This model maps PEs into courses based on what concepts are needed for support without focusing on keeping disciplines separate (Source NGSS.org - Appendix K).

It was also noted that states such as California and Kentucky have adopted the NGSS conception progressions model for 6th, 7th and 8th.

A. Further clarification of recommendation

We have identified numerous NGSS standards K-12 that address…

<u>Sixth grade standards</u>

- **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.**
- **MS-LS1-2. Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.**

- **MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.**
- **MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.**
- **MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.**
- **MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.**
- **MS-PS1-5. Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.**
- **MS-PS-6. Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.***
- **MS-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.***
- **MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.**
- **MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.**
- **MS-PS2-4. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.**

- **MS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.**
- **MS-PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.**
- **MS-PS3-2. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.**
- **MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.***
- **MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.**
- **MS-PS3-5. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.**
- **MS-PS4-1. Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.**
- **MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.**

- **MS-ESS1-1. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.**
- **MS-ESS1-2. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.**
- **MS-ESS1-3. Analyze and interpret data to determine scale properties of objects in the solar system.**
- **MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.**
- **MS-EES2-6. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.**
- **MS-EE3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.**

- **MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.**
- **MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.**
- **MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.**

Seventh grade standards

- **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.**
- **MS-LS1-2. Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.**
- **MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.**

- **MS-LS1-4. Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.**
- **MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.**
- **MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.**
- **MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.**
- **MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.**
- **MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.**
- **MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.**
- **MS-LS3-1. Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.**
- **MS-LS3-2. Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.**

- **MS-P24-3. Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.**

- **MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.**
- **MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.**
- **MS-ESS2-6. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.**

- **MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.**
- **MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.**
- **MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.**
- **MS-ETS1-3. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.**

<u>Eighth grade standards</u>

- **MS-LS1-8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.**
- **MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.**

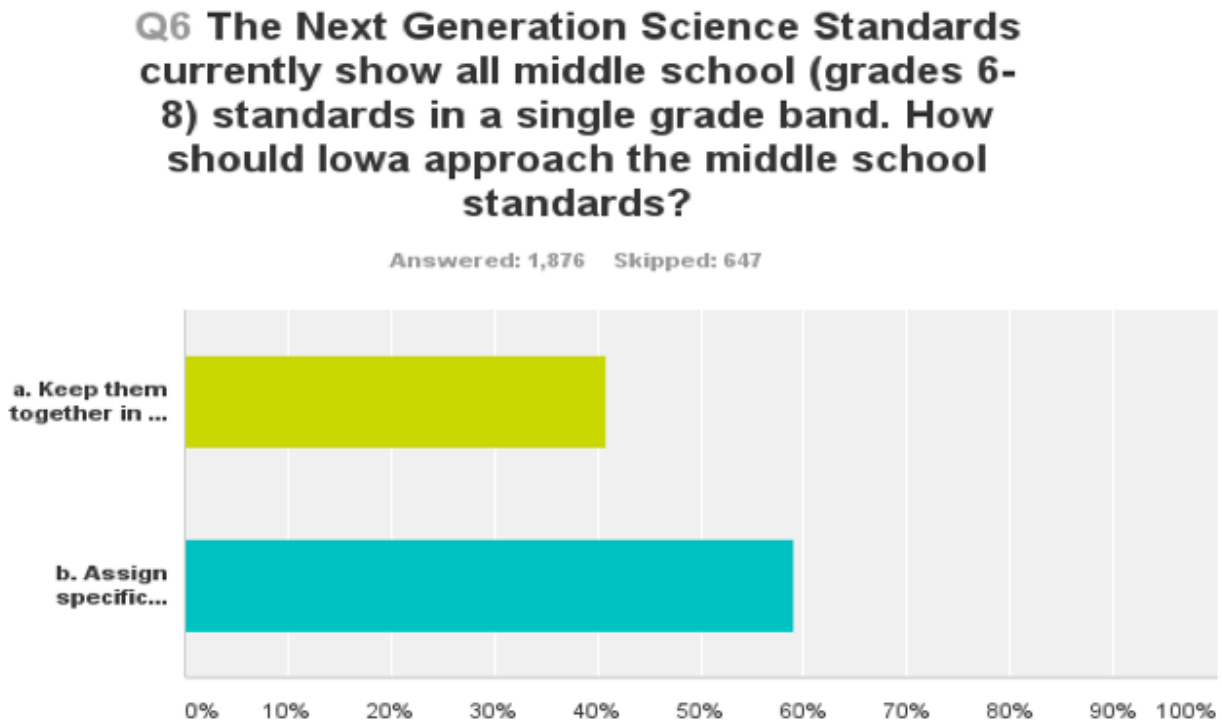
- **MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.***
- **MS-LS4-1. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.**
- **MS-LS4-2. Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.**
- **MS-LS4-3. Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.**
- **MS-LS4-4. Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.**
- **MS-LS4-5. Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.**
- **MS-LS4-6. Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.**

- **MS-ESS1-4. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.**
- **MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.**
- **MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.**
- **MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.**

- **MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.**
- **MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.**
- **MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.**
- **MS-ETS1-3. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.**

B. Referring to data/feedback/comments

Public feedback supports assigning specific standards to each grade level:



Our large group discussion and recommendation from March 24, 2015:

Concern: Mobility of students across grades 6-8.

These students don't have the opportunity as H.S. students do, to design their schedule. They must take the science offered in that MS grade level. The mobility for middle school students is high (i.e. Des Moines School District Middle Schools — 25%-30%). It was decided that the team needed to designate grade levels in MS for the NGSS.

Since science disciplines are interrelated and not silos, the team determined it was better to integrate (spiral) the curriculum so students could develop deeper understanding in the sciences. This also is supported by the public feedback.

If NGSS is adopted, the respondents are split (40%-60%) on whether the state should have middle school standards as a single grade band or separate them into specific 6th, 7th, and 8th grade standards. Of the 1536 (60.1%) respondents who self-identified as being directly involved in science education, 251 (16.3%) people did not answer the item on whether to keep standards in a grade band or separate them into specific grade standards.

Of the self-identified people who are involved in science education and answered the item (1285), 722 (56%) wanted specific grade level standards and 563 (44%) wanted a grade band. This matches the approximately 60/40 split of the whole group.

When looking at the respondents who provided comments to this question:

- 503 educators who provided comments to this item, 229 (46%) suggested single band and 274 (54%) suggested grade level.

- 43 administrators who responded, 16 (37%) wanted single band; 27 (63%) wanted grade level.
- 17 AEA respondents, 5 (29%) wanted single band and 12 (71%) wanted grade level.
- 30 higher education respondents, 20 (67%) suggested single band; 10 (33%) suggested grade level.
- 10 students who responded, 3 (30%) wanted single band; 7 (70%) wanted grade level.
- 196 respondents who identified themselves as parent, community member, business or other, 70 (36%) suggested single band and 126 (64%) wanted grade level.

Overall, the people most directly involved with K-12 science education and professional development (teachers, administrators, AEA personnel), 250 (44%) suggested single band and 313 (56%) suggested grade level.

Most of the comments for single band, focused on wanting local control, providing districts with the opportunity to not change what they are currently doing, or allowing for more project-based models.

Comments for grade level specific focused on consistency of expectations across the state, concerns about students moving from district to district and re-learning the same information or missing information completely, allowing for more specific professional development, providing a sequence of instruction that allows students to experience some earth, physical and life science each year in a developmentally appropriate manner that allows for more advanced standards at each grade level.

Overall, within the education community and the broader community, there does not seem to be agreement on whether middle school (6-8) standards should be a single grade band or grade-level specific. The team reviewed statewide data on the number of students who transfer between and among schools and considered educational research supporting integration of disciplinary core concepts.

Based on these data, the team recommends the adoption of grade-specific integrated standards for grades 6-8. The team recommends to consider using Conceptual Progression Model One described in Appendix K.

C. Additional recommendations

Recommendations based on the identified issues from the feedback or as specified in Executive Order 83.

Issue or Concern Addressed:

It is important to ensure that Iowa adopt standards that will prepare graduates to be college and career ready.

Executive Order "...WHEREAS, rigorous state standards detailing expected academic achievement are essential to provide a high -quality education, which is key to students' futures and the future of this state…"

Recommendation:
The team recommends adopting the performance expectations of NGSS as the Iowa Core science standards.

A. Further clarification of recommendation

B. Referring to data/feedback/comments

At the public forums, participants indicated they wanted their children and all Iowa students to have rigorous standards that will prepare them for college and careers. In addition, Executive Order 83 states the following: "...WHEREAS, rigorous state standards detailing expected academic achievement are essential to provide a high-quality education, which is key to students' futures and the future of this state;..."

In the area of ensuring that Iowa adopts standards that will prepare graduates to be college and career ready, over 68% of the people who responded to the question on the survey indicate that the breadth and depth of the Next Generation Science Standards would prepare graduates to be ready for college, careers, and other post-secondary options. From the respondents, 660 comments were given. Of the 457 teachers, administrators, and AEA personnel who provided comments to the question, 309 (67.6%) agree or strongly agree that the NGSS will prepare students to be college and career ready, 87 (19%) are neutral, and 61 (13.3%) disagree or strongly disagree.

Those who disagree that the standards will adequately prepare all students provided comments that focused on the content being too rigorous for ALL students and including too much Earth Science. There were a few comments about the lack of upper level chemistry or physics and not enough content-related to health and the human body.

It is important to remember standards are the minimum requirements for all students and that those who are planning to major in science will need/want to take more advanced courses. Of the 197 higher education, student, parent, community member, business and "other" classification who responded to the question, 118 (59.9%) agree or strongly agree NGSS will prepare students to be college and career ready; 39 (19.8%) were neutral, and 40 (20.3%) disagree or strongly disagree.

Public forum comments indicated some concern with the NGSS rating of a "C" on the Fordham report and a concern that other states had standards that ranked higher on the Fordham report. The team reviewed the Fordham report and the states that have adopted NGSS.* They also noted that several of the states whose standards had scored an A or B had either already adopted NGSS or were in the process of adopting/adapting.

The team also considered the public comments that addressed the correlation between ACT scores of students, noting that those state scores showed little significant difference in those that had lower Fordham grades and those students in states who scored A or B on the Fordham.

*States that have adopted NGSS and those receiving Fordham A or B:

1. Rhode Island (May 23, 2013)
2. California (Fordham gave them an A.)
3. Delaware
4. Illinois
5. Kansas (Fordham gave them a B.)
6. Kentucky
7. Maryland (Fordham gave them a B.)
8. Rhode Island
9. Vermont
10. Oregon
11. Nevada Washington
12. New Jersey
13. District of Columbia (Fordham gave them an A.)
14. West Virginia (December 10, 2014)

C. Additional recommendations

Recommendations based on the identified issues from the feedback or as specified in Executive Order 83.

Issue or Concern Addressed:
Where should health/wellness/human body systems/nutrition be addressed.

Recommendation:
No change to NGSS.

A. Further clarification of recommendation

We have identified numerous NGSS standards K-12 that may address this concern

- K-LS1-1. Use observations to address patterns of what plants and animals (including humans) need to survive.
- 1-LS-1-1. Use materials to design a solution to a human problem by mimicking how plants and or animals use their external parts to help them survive, grow and meet their needs
- 3-LS1-1. Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.
- 4-LS-1-2. Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.
- MS-LS-1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
- MS-LS-1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
- MS-LS-1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.
- HS-LS-1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms
- HS-LS-1-3. Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.
- HS-LS-1-7. Use a model to illustrate that cellular respiration is a chemical process whereby the bonds of food molecules and oxygen molecules are broken and the bonds in new compounds are formed resulting in a net transfer of energy.

B. Referring to data/feedback/comments

Survey Comment Feedback:
That human body systems should be addressed in the high school standard. (LSI)
Is this where human body systems should be placed? With the obesity rate in the U.S., we should have nutrition and how your body works somewhere. (LSI)

Question 11 What are concerns you have about NGSS?
Out of 938 response there were 9 comments (1%) related to health and wellness.

C. Additional recommendations

- It is our recommendation that Health and Wellness are already addressed in the Health Literacy Standards (21st Century Skills) in the Iowa Core with no change to NGSS.

Recommendations based on the identified issues from the feedback or as specified in Executive Order 83.

Issue or Concern Addressed:
Should biological evolution be the only theory utilized in the NGSS?

Recommendation:

No change recommended to Life Sciences Standards regarding biological evolution.

A. Further clarification of recommendation

Biological evolution is the primary theoretical model behind present-day biology, which unifies and underlies all life sciences.

B. Referring to data/feedback/comments
Of the 2,532 respondents, 938 comments were given in response to the question, "What are your concerns related to NGSS?" Twenty-seven comments (2.9%) concerned the subject of biological evolution. Sixteen comments (1.7%) negatively referenced biological evolution as a science standard.

Although a small number of respondents to our public feedback survey (less than 0.1%) expressed concern, the team supports the standard of biological evolution: *Unity and Diversity*, as the basis for understanding all the natural sciences. The evidence from Iowa's public comment data is similar to data collected nationally in regard to the NGSS. A very small percentage of the public have expressed concern about including biological evolution in the standards.

C. Additional recommendations

Recommendations based on the identified issues from the feedback or as specified in Executive Order 83.

Issue or Concern Addressed:
The following Disciplinary Core Ideas should be eliminated. No reasons were noted. This concern was expressed from 4 of the 2523 respondents (.2%).
ESS2D: ***Weather and Climate***
ESS3C: ***Human Impacts on Earth Systems***
ESS3D: ***Global Climate Change***

Recommendation:

No changes to NGSS ESS2D: Weather and Climate; ESS3C Human Impacts on Earth Systems and ESS3D Global Climate Change.

A. Further clarification of recommendation

The concerns are not included in the standards ("performance expectations").

B. Referring to data/feedback/comments

The issue brought forth about climate change is related to human activities described in the NGSS document in the disciplinary core ideas section. Disciplinary core ideas are concepts in physical sciences; life sciences; earth and space sciences; and engineering, technology, and applications of science that have broad importance and lead to deeper understanding and application. This section of the document is aimed at providing guidance for educators. It is not providing standards.

C. Additional recommendations

Recommendations based on the identified issues from the feedback or as specified in Executive Order 83.

Issue or Concern Addressed:

A petition was sent in urging the adoption of the NGSS, specifically asking that we keep intact the climate science (i.e. ESS3 Earth and Human Activity).

Recommendation:
No changes to Earth and Space Sciences standards.

A. Further clarification of recommendation

The ESS3 is about Earth and Human Activity. It includes MS - middle school and HS - high school. There are eleven standards combined.

"*In the ESS3 performance expectations, students are expected to demonstrate proficiency in asking questions, developing and using models, analyzing and interpreting data, constructing explanations and designing solutions and engaging in argument; and to use these practices to demonstrate understanding of the core ideas" (NGSS.org/storylines)*

B. Referring to data/feedback/comments

Petition signed by 307 people concerned that we might alter the climate change aspect of NGSS. In the petition the author states, "The climate science content in the NGSS was written and peer-reviewed by scientists and science educators, and represents the scientific consensus on climate change. The American Meteorological Society said climate science 'is as sound as other NGSS subjects such as earthquakes and the solar system.'"

C. Additional recommendations

Recommendations based on the identified issues from the feedback or as specified in Executive Order 83.

Issue or Concern Addressed: The words "over the past century" in the standard MS-ESS 3-5 "*Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.*"

Recommendation:

No change in standard/performance expectation.

A. Further clarification of recommendation

There was one respondent addressing this issue (.04%). The rationale for addressing one respondent was due to the fact that it did address a standard versus all other feedback that were non-standards-based.

B. Referring to data/feedback/comments

One respondent expressed concern about addressing multiple climate data sets is necessary as opposed to the current wording of "one century."

The comment: "Addressing multiple data sets, long-term data (thousands of years vs. only the past 100 or 200 or 300 years, is necessary)"

The statement in this standard about "the last century" encourages evidence-based cause for factors impacting global temperature. It does not eliminate or discourage reviewing evidence prior to this time frame.

C. Additional recommendations

Recommendations based on the identified issues from the feedback or as specified in Executive Order 83.

Issue or Concern Addressed in Public Feedback: Science teachers are uncomfortable teaching engineering design practices.

Recommendation: No changes to NGSS regarding engineering

A. Further clarification of recommendation

We have identified the NGSS standards K-12 that address engineering design.

Examples:

- K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.
- K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
- K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.
- 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
- MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.
- HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
- HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

B. Referring to data/feedback/comments…

We anticipate that the insights gained and interests provoked from studying and engaging in the practices of science and engineering during their K-12 schooling should help students see how science and engineering are instrumental in addressing major challenges that confront society today, such as

generating sufficient energy, preventing and treating diseases, maintaining supplies of clean water and food, and solving the problems of global environmental change. (National Research Council 2012, p. 9)

Public feedback, specifically Question 11, offered 9 out of 89 (10%) negative comments about the inclusion of engineering practices (see Public Comment Testimonials below):

- *They weigh much more heavily towards engineering than real science. Science is about discovery, obtaining real world, quanti[ta]tive data, forming theories, doing experiments, finding out how & why things work. Engineering is the exact opposite: it's about using provided qualitative data, design, implementation, & making things work. By leaning so heavily on engineering & the associated labs, children are taught to value skills practices over knowledge, the latter of which ultimately is the true purpose of education. As an engineer, I am a bit concerned that these standards are untested for efficacy, which ironically, is actually contrary to both the science and engineering practices themselves. Why would we do something that risky, especially to our most precious resource, our children?* (Other, Work in STEM)

Public feedback, specifically Question 10, also offered 80 out of 89 (90%) positive comments for the inclusion of engineering practices (see Public Comment Testimonials below):

- *I like the inclusion of engineering in the Standards. I do believe we need to continue to encourage and push students towards the skills and knowledge needed to become successful engineers, in a variety of fields. We are missing a great opportunity with the next generation if we do not make this a major emphasis.* (Parent)
- *They focus on actively "doing" science. Students will gain not only science content but crucial critical thinking skills and combined with the level of engineering design that is built into all standards I believe that NextGen standards will truly give our students the 21st century skills they need to be successful. (Parent & Teacher)*
- Refer to Appendix I: Engineering Design in NGSS

Engineering standards have been integrated throughout the science domains of physical science, life science, and earth and space science as evidenced in the chart below.

Performance Expectations That Incorporate Engineering Practices

	Physical Science	Life Science	Earth and Space Science	Engineering
K	K-PS2-2 K-PS3-2		K-ESS3-2 K-ESS3-3	K-2-ETS1-1 K-2-ETS1-2 K-2-ETS1-3
1	1-PS4-4	1-LS1-1		
2	2-PS1-2	2-LS2-2	2-ESS2-1	
3	3-PS2-4	3-LS4-4	3-ESS3-1	3-5-ETS1-1
4	4-PS3-4 4-PS4-3		4-ESS3-2	3-5-ETS1-2 3-5-ETS1-3
5				
6-8	MS-PS1-6 MS-PS2-1 MS-PS3-3	MS-LS2-5		MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4
9-12	HS-PS1-6 HS-PS2-3 HS-PS2-6 HS-PS3-3 HS-PS4-5	HS-LS2-7 HS-LS4-6	HS-ESS3-2 HS-ESS3-4	HS-ETS1-1 HS-ETS1-2 HS-ETS1-3 HS-ETS1-4

C. Additional recommendations

Additional Professional Development Recommended for Science Teachers

- Specifically in engineering pedagogy
- Examples of sources to draw on to support teachers: ITTEA, ABET, ASEE, ACTE
- PLC and common planning time for science/engineering teachers
- Characteristics of effective instruction - see **Iowa Core**
- Support provided by AEAs can supplement teacher PD

Appendix 4: Recommended Iowa Science Standards

K-PS2 Motion and Stability: Forces and interactions
Students who demonstrate understanding can: **K-PS2-1. Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.** **K-PS2-2. Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.***

K-PS3 Energy
Students who demonstrate understanding can: **K-PS3-1. Make observations to determine the effect of sunlight on Earth's surface** **K-PS3-2. Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.***

K-LS1 From Molecules to Organisms: Structures and Processes
Students who demonstrate understanding can: **K-LS1-1. Use observations to describe patterns of what plants and animals (including humans) need to survive.**

K-ESS2 Earth's Systems
Students who demonstrate understanding can: **K-ESS2-1. Use and share observations of local weather conditions to describe patterns over time.** **K-ESS2-2. Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.**

K-ESS3 Earth and Human Activity
Students who demonstrate understanding can: **K-ESS3-1. Use a model to represent the relationship between the needs of different plants or animals (including humans) and the places they live.** **K-ESS3-2. Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather.*** **K-ESS3-3. Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.***

K-2-ETS1 Engineering Design
Students who demonstrate understanding can: **K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.** **K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.** **K-2-ETS1-3. Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.**

1-PS4 Waves and their Applications in Technologies for Information Transfer
Students who demonstrate understanding can:

1-PS4-1. Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.
1-PS4-2. Make observations to construct an evidence-based account that objects can be seen only when illuminated.
1-PS4-3. Plan and conduct an investigation to determine the effect of placing objects made with different materials in the path of a beam of light.
1-PS4-4. Use tools and materials to design and build a device that uses light or sound to solve the problem of communicating over a distance.*

1-LS1 From Molecules to Organisms: Structures and Processes
Students who demonstrate understanding can: **1-LS1-1. Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.*** **1-LS1-2. Read texts and use media to determine patterns in behavior of parents and offspring that help offspring survive.**

1-LS3 Heredity: Inheritance and Variation of Traits
Students who demonstrate understanding can: **1-LS3-1. Make observations to construct an evidence-based account that young plants and animals are like, but not exactly like, their parents.**

1-ESS1 Earth's Place in the Universe
Students who demonstrate understanding can: **1-ESS1-1. Use observations of the sun, moon, and stars to describe patterns that can be predicted.** **1-ESS1-2. Make observations at different times of year to relate the amount of daylight to the time of year.**

2-PS1 Matter and its Interactions
Students who demonstrate understanding can: **2-PS1-1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.** **2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.*** **2-PS1-3. Make observations to construct an evidence-based account of how an object made of a small set of pieces can be disassembled and made into a new object.** **2-PS1-4. Construct an argument with evidence that some changes caused by heating or cooling can be reversed and some cannot.**

2-LS2 Ecosystems: Interactions, Energy, and Dynamics
Students who demonstrate understanding can: **2-LS2-1. Plan and conduct an investigation to determine if plants need sunlight and water to grow.** **2-LS2-2. Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.***

2-LS4 Biological Evolution: Unity and Diversity
Students who demonstrate understanding can: **2-LS4-1. Make observations of plants and animals to compare the diversity of life in different habitats.**

2-ESS1 Earth's Place in the Universe
Students who demonstrate understanding can: **2-ESS1-1. Use information from several sources to provide evidence that Earth events can occur quickly or slowly.**

2-ESS2 Earth's Systems
Students who demonstrate understanding can: **2-ESS2-1. Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.*** **2-ESS2-2. Develop a model to represent the shapes and kinds of land and bodies of water in an area.** **2-ESS2-3. Obtain information to identify where water is found on Earth and that it can be solid or liquid.**

3-PS2 Motion and Stability: Forces and Interactions
Students who demonstrate understanding can: **3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.** **3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.** **3-PS2-3. Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.** **3-PS2-4. Define a simple design problem that can be solved by applying scientific ideas about magnets.***

3-LS1 From Molecules to Organisms: Structures and Processes
Students who demonstrate understanding can: **3-LS1-1. Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.**

3-LS2 Ecosystems: Interactions, Energy, and Dynamics
Students who demonstrate understanding can: **3-LS2-1. Construct an argument that some animals form groups that help members survive.**

3-LS3 Heredity: Inheritance and Variation of Traits
Students who demonstrate understanding can: **3-LS3-1. Analyze and interpret data to provide evidence that plants and animals have traits inherited from parents and that variation of these traits exists in a group of similar organisms.** **3-LS3-2. Use evidence to support the explanation that traits can be influenced by the environment.**

3-LS4 Biological Evolution: Unity and Diversity
Students who demonstrate understanding can: **3-LS4-1. Analyze and interpret data from fossils to provide evidence of the organisms and the environments in which they lived long ago.** **3-LS4-2. Use evidence to construct an explanation for how the variations in characteristics among individuals of the same species may provide advantages in surviving, finding mates, and reproducing.**

3-LS4-3. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.
3-LS4-4. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.*

3-ESS2 Earth's Systems
Students who demonstrate understanding can: **3-ESS2-1. Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.** **3-ESS2-2. Obtain and combine information to describe climates in different regions of the world.**

3-ESS3 Earth and Human Activity
Students who demonstrate understanding can: **3-ESS3-1. Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.***

4-PS3 Energy
Students who demonstrate understanding can: **4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.** **4-PS3-2. Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.** **4-PS3-3. Ask questions and predict outcomes about the changes in energy that occur when objects collide.** **4-PS3-4. Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.***

4-PS4 Waves and their Applications in Technologies for Information Transfer
Students who demonstrate understanding can: **4-PS4-1. Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.** **4-PS4-2. Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.** **4-PS4-3. Generate and compare multiple solutions that use patterns to transfer information.***

4-LS1 From Molecules to Organisms: Structures and Processes
Students who demonstrate understanding can: **4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.** **4-LS1-2. Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.**

4-ESS1 Earth's Place in the Universe
Students who demonstrate understanding can: **4-ESS1-1. Identify evidence from patterns in rock formations and fossils in rock layers to support an explanation for changes in a landscape over time.**

4-ESS2 Earth's Systems

Students who demonstrate understanding can:

4-ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.

4-ESS2-2. Analyze and interpret data from maps to describe patterns of Earth's features.

4-ESS3 Earth and Human Activity
Students who demonstrate understanding can: **4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.** **4-ESS3-2. Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.***

5-PS1 Matter and Its Interactions
Students who demonstrate understanding can: **5-PS1-1. Develop a model to describe that matter is made of particles too small to be seen.** **5-PS1-2. Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.** **5-PS1-3. Make observations and measurements to identify materials based on their properties.** **5-PS1-4. Conduct an investigation to determine whether the mixing of two or more substances results in new substances.**

5-PS2 Motion and Stability: Forces and Interactions
Students who demonstrate understanding can: **5-PS2-1. Support an argument that the gravitational force exerted by Earth on objects is directed down.**

5-PS3 Energy
Students who demonstrate understanding can: **5-PS3-1. Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun.**

5-LS1 From Molecules to Organisms: Structures and Processes
Students who demonstrate understanding can: **5-LS1-1. Support an argument that plants get the materials they need for growth chiefly from air and water.**

5-LS2 Ecosystems: Interactions, Energy, and Dynamics
Students who demonstrate understanding can: **5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.**

5-ESS1 Earth's Place in the Universe
Students who demonstrate understanding can: **5-ESS1-1. Support an argument that differences in the apparent brightness of the sun compared to other stars is due to their relative distances from Earth.** **5-ESS1-2. Represent data in graphical displays to reveal patterns of daily changes in length and direction of shadows, day and night, and the seasonal appearance of some stars in the night sky.**

5-ESS2 Earth's Systems
Students who demonstrate understanding can: **5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.** **5-ESS2-2. Describe and graph the amounts and percentages of water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.**

5-ESS3 Earth and Human Activity
Students who demonstrate understanding can: **5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.**

3-5-ETS1 Engineering Design
Students who demonstrate understanding can: **3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.** **3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.** **3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.**

6th Grade

MS-PS1 Matter and Its Interactions
Students who demonstrate understanding can: **MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.** **MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.** **MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.** **MS-PS1-5. Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.** **MS-PS1-6. Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.***

MS-ESS2 Earth's Systems
Students who demonstrate understanding can: **MS-ESS2-1. Develop a model to describe the cycling of Earth's materials and the flow of energy that drives this process.** **MS-ESS2-2. Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales.** **MS-ESS2-3. Analyze and interpret data on the distribution of fossils and rocks, continental shapes, and seafloor structures to provide evidence of the past plate motions.**

MS-ESS3 Earth and Human Activity
Students who demonstrate understanding can:

MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes.
MS-ESS3-2. Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects.

MS-LS1 From Molecules to Organisms: Structures and Processes

Students who demonstrate understanding can:

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.
MS-LS1-2 Develop and use a model to describe the function of a cell as a whole and ways parts of cells contribute to the function.
MS-LS1-3 Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
MS-LS1-8 Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.
MS-LS3-2. Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.

MS-ETS1 Engineering Design

Students who demonstrate understanding can:

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

7th Grade

MS-PS2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

MS-PS2-3. Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.
MS-PS2-4. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
MS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.

MS-PS3 Energy

Students who demonstrate understanding can:

MS-PS3-2. Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.
MS-PS3-4. Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.

MS-PS3-5. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

MS-ESS1 Earth's Place in the Universe
Students who demonstrate understanding can: **MS-ESS1-1. Develop and use a model of the Earth-sun-moon system to describe the cyclic patterns of lunar phases, eclipses of the sun and moon, and seasons.** **MS-ESS1-2. Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system.** **MS-ESS1-3. Analyze and interpret data to determine scale properties of objects in the solar system.** **MS-ESS1-4. Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history.**

MS-LS1 From Molecules to Organisms: Structures and Processes
Students who demonstrate understanding can: **MS-LS1-4 Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively.** **MS-LS1-5 Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.** **MS-LS1-6 Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.** **MS-LS1-7 Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.**

MS-LS2 Ecosystems: Interactions, Energy, and Dynamics
Students who demonstrate understanding can: **MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem.** **MS-LS2-2. Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.** **MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.** **MS-LS2-4. Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.**

MS-LS3 Heredity: Inheritance and Variation of Traits
Students who demonstrate understanding can: **MS-LS3-1. Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism.**

MS-ETS1 Engineering Design
Students who demonstrate understanding can: **MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.** **MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.**

MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

8th Grade

MS-PS1 Matter and Its Interactions

Students who demonstrate understanding can:

MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.

MS-PS2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

MS-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.*
MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

MS-PS3 Energy

Students who demonstrate understanding can:

MS-PS3-1. Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.
MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.*

MS-PS4 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

MS-PS4-1. Use mathematical representations to describe a simple model for waves that includes how the amplitude of a wave is related to the energy in a wave.
MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
MS-PS4-3. Integrate qualitative scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.

MS-LS2 Ecosystems: Interactions, Energy, and Dynamics

Students who demonstrate understanding can:

MS-LS2-5. Evaluate competing design solutions for maintaining biodiversity and ecosystem services.*

MS-LS4 Biological Evolution: Unity and Diversity

Students who demonstrate understanding can:

MS-LS4-1. Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past.
MS-LS4-2. Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships.

MS-LS4-3. Analyze displays of pictorial data to compare patterns of similarities in the embryological development across multiple species to identify relationships not evident in the fully formed anatomy.
MS-LS4-4. Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.
MS-LS4-5. Gather and synthesize information about the technologies that have changed the way humans influence the inheritance of desired traits in organisms.
MS-LS4-6. Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time.

MS-ESS2 Earth's Systems
Students who demonstrate understanding can:
MS-ESS2-4. Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
MS-ESS2-5. Collect data to provide evidence for how the motions and complex interactions of air masses results in changes in weather conditions.
MS-ESS2-6. Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

MS-ESS3 Earth and Human Activity
Students who demonstrate understanding can:
MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.*
MS-ESS3-4. Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.
MS-ESS3-5. Ask questions to clarify evidence of the factors that have caused the rise in global temperatures over the past century.

MS-ETS1 Engineering Design
Students who demonstrate understanding can:
MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

HS-PS1 Matter and Its Interactions
Students who demonstrate understanding can:
HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.
HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
HS-PS1-6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.*
HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
HS-PS1-8. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay.

HS-PS2 Motion and Stability: Forces and Interactions
Students who demonstrate understanding can:
HS-PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*
HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.
HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.*

HS-PS3 Energy
Students who demonstrate understanding can:
HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*
HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).
HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

HS-PS4 Waves and Their Applications in Technologies for Information Transfer
Students who demonstrate understanding can:
HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
HS-PS4-2. Evaluate questions about the advantages of using a digital transmission and storage of information.
HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.
HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.*

HS-LS1 From Molecules to Organisms: Structures and Processes
Students who demonstrate understanding can: **HS-LS1-2. Develop and use a model to illustrate the hierarchical organization of interacting systems that provide specific functions within multicellular organisms.**

HS-LS2 Ecosystems: Interactions, Energy, and Dynamics
Students who demonstrate understanding can: **HS-LS2-1. Use mathematical and/or computational representations to support explanations of factors that affect carrying capacity of ecosystems at different scales.** **HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.** **HS-LS2-3. Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.** **HS-LS2-4. Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.** **HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.** **HS-LS2-6. Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.** **HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*** **HS-LS2-8. Evaluate the evidence for the role of group behavior on individual and species' chances to survive and reproduce.**

HS-LS3 Heredity: Inheritance and Variation of Traits
Students who demonstrate understanding can: **HS-LS3-1. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.** **HS-LS3-2. Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.** **HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.**

HS-LS4 Biological Evolution: Unity and Diversity
Students who demonstrate understanding can: **HS-LS4-1. Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.** **HS-LS4-2. Construct an explanation based on evidence that the process of evolution primarily results from four factors: (1) the potential for a species to increase in number, (2) the heritable genetic variation of individuals in a species due to mutation and sexual reproduction, (3) competition for limited resources, and (4) the proliferation of those organisms that are better able to survive and reproduce in the environment.** **HS-LS4-3. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait.** **HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations.**

HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
HS-LS4-6. Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.*

HS-ESS1 Earth's Place in the Universe

Students who demonstrate understanding can:

HS-ESS1-1. Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.
HS-ESS1-2. Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.
HS-ESS1-3. Communicate scientific ideas about the way stars, over their life cycle, produce elements.
HS-ESS1-4. Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
HS-ESS1-5. Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.
HS-ESS1-6. Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.

HS-ESS2 Earth's Systems

Students who demonstrate understanding can:

HS-ESS2-1. Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.
HS-ESS2-2. Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.
HS-ESS2-3. Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.
HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
HS-ESS2-5. Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.
HS-ESS2-6. Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
HS-ESS2-7. Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.

HS-ESS3 Earth and Human Activity

Students who demonstrate understanding can:

HS-ESS3-1. Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
HS-ESS3-2. Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*
HS-ESS3-3. Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.
HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*
HS-ESS3-5. Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.

HS-ESS3-6. Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

HS-ETS1 Engineering Design
Students who demonstrate understanding can: **HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.** **HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.** **HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.** **HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.**