NEXT GENERATION SCIENCE STANDARDS

MS-ETS-ED Engineering Design

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Students who demonstrate understanding can:

a. **Evaluate ideas for solving an environmental problem to determine which designs best meet the criteria and constraints of the problem and take into account scientific principles and short and long-term consequences.** [Clarification Statement: Students compare sand blasting, chemical solvent, and high heat for removing graffiti; evaluate different plans for solving problems due to invasive species.] [*Assessment Boundary: A numerical weighting system may be used to evaluate designs, but not an advanced mathematical model.*]

b. **Develop a better design by combining characteristics of different solutions to arrive at a design that takes into account relevant scientific principles and better meets the needs of society.** [Clarification Statement: For example, students develop a design for a highly energy efficient automobile by combining ideas from different car ads.] [*Assessment Boundary: Limit arguments to qualitative characteristics.*]

c. **Compare different designs by building physical models and running them through the same kinds of tests, while systematically controlling variables and recording the results to determine which design performs best.** [Clarification Statement: For example, students test different designs for a bridge by building and testing a model or compare different designs for a hydroponic farm by building and testing small scale models in the classroom.]

d. **Use a computer simulation to test the effectiveness of a design under different operating conditions, or test what would happen if parameters of the model were changed, noting how the simulation may be limited in accurately modeling the real world.** [Clarification Statement: Examples include simulating how a solar hot water system would function in different seasons or parts of the world and simulating the effects of different preventive actions in slowing the spread of disease during an epidemic.] [*Assessment Boundary: Students should be given simulation software to use and not expected to create their own.*]

e. **Refine a design by conducting several rounds of tests, modifying the model after each test, to create the best possible design that meets the most important criteria.** [Clarification Statement: For example, students refine the design of a model building to withstand an earthquake, strengthening failure points after each test, or refine the design of a water filtration system by adding physical and chemical components and retesting after each change.]

f. **Communicate information about a proposed solution to a problem, including relevant scientific principles, how the design was developed, how it meets the criteria and constraints of the problem, and how it reduces the potential for negative consequences for society and the natural environment.** [Clarification Statement: Students develop a poster, slide presentation, or oral design concept presentation.] [*Assessment Boundary: Arguments should be limited to qualitative characteristics.*]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Planning and Carrying Out Investigations
Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.
- Plan and carry out investigations individually and collaboratively, identifying independent and dependent variables and controls. (c)
- Collect data and generate evidence to answer scientific questions or test design solutions. (c)

Using Mathematics and Computational Thinking
Mathematical and computational thinking at the 6–8 level builds on K–5 and progresses to identifying patterns in large data sets and using mathematical concepts to support explanations and arguments.
- Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends. (d)
- Use mathematical arguments to justify scientific conclusions and design solutions. (d)

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.
- Undertake design projects, engaging in the design cycle, to construct and implement a solution that meets specific design criteria and constraints. (b),(e)

Obtaining, Evaluating, and Communicating Information

Disciplinary Core Ideas

ETS1.A: Defining and Delimiting an Engineering Problem
- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. (a)
- Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (a)

ETS1.B: Developing Possible Solutions
- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (e)
- There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (a)
- It is important to be able to communicate and explain solutions to others. (f)
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (b)
- Models of all kinds are important for testing solutions, and computers are a valuable tool for simulating systems. (d)
- Simulations are useful for predicting what would happen if various parameters of the model were changed, as well as for making improvements to the model based on peer and leader (e.g., teacher) feedback. (d)

ETS1.C: Optimizing the Design Solution
- Comparing different designs could involve running them through the same kinds of tests and systematically recording the results to determine which design performs best. (c)

Crosscutting Concepts

Cause and Effect
Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. Cause and effect relationships may be used to predict phenomena in natural or designed systems. Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. (a),(e)

Systems and System Models
Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems. Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy, matter, and information flows within systems. Models are limited in that they only represent certain aspects of the system under study. (c),(d)

Connections to Engineering, Technology, and Applications of Science

Influence of Engineering, Technology, and Science on Society and the Natural World
All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. The uses of technologies are driven by people's needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and

Obtaining, evaluating, and communicating information in 6–8 builds on 3–5 and progresses to evaluating the merit and validity of ideas and methods. • Generate and communicate ideas and methods using scientific language and reasoning. (a),(f)	• Although one design may not perform the best across all tests, Identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process-that is, some of those characteristics may be incorporated into the new design. (c) • This iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (e) • Once a suitable solution is determined, it is important to describe that solution, explain how it was developed, and describe the features that make it successful. (f)	economic conditions. Thus technology use varies from region to region and over time. (a),(b),(f)

Connections to other DCIs in this grade-level: **MS.ES-HI, MS.LS-GDRO, MS.PS-IF, MS.PS-E, MS.ETS-ETSS**

Articulation of DCIs across grade-levels: **1.SF, 2.ECS, 2.PP, 4.E, 4.PSE, 4.WAV, HS.ETS-ED**

Common Core State Standards Connections: [Note: these connections will be made more explicit and complete in future draft releases]

ELA -

RST.6.3	Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
W.6.1	Write arguments to support claims with clear reasons and relevant evidence.
W.7.1	Write arguments to support claims with clear reasons and relevant evidence.
W.8.1	Write arguments to support claims with clear reasons and relevant evidence.
WHST.7	Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration..

Mathematics -

MP.1	Make sense of problems and persevere in solving them.
MP.2	Reason abstractly and quantitatively.
MP.4	Model with mathematics.
MP.6	Attend to precision.
6.EE	Apply and extend previous understandings of arithmetic to algebraic expressions. Represent and analyze quantitative relationships between dependent and independent variables.
7.RP	Analyze proportional relationship and use them to solve real-world and mathematical problems.
7.EE	Solve real-life and mathematical problems using numerical and algebraic expressions and equations.
8.F	Use functions to model relationships between quantities.

MS-ETS-ETSS Links Among Engineering, Technology, Science, and Society

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Students who demonstrate understanding can:

a. **Provide examples to explain how advances in engineering have resulted in new tools and instruments for measurement, exploration, modeling, and computation that enable new scientific discoveries, which in turn lead to the development of entire industries and engineered systems.** [Clarification Statement: Examples include: microscopes enabled the germ theory of disease, which led to the development of antibiotics, stimulating growth of the pharmaceutical industry; discoveries in physics led to development of the integrated circuit, and computers, leading to many scientific breakthroughs, and spawning new industries.]

b. **Obtain, evaluate, and communicate information about a technology that draws on natural resources to improve health of people and the natural environment, and was eventually found to have negative impacts, requiring regulations on its use or new technologies to reduce its negative impacts.** [Clarification Statement: Examples include the introduction of new chemicals for refrigeration that were less toxic, but were later found to reduce the ozone layer; the adoption of fossil fuels for energy that eliminated the need to decimate forests for heating and cooking, but were later found to change the atmosphere and climate.]

c. **Construct an explanation for how a technological system has changed over time, based on evidence about how these changes were driven by: (1) people's changing needs, desires, and values, (2) the findings of scientific research, and (3) factors such as climate, natural resources, and economic conditions.** [Clarification Statement: Use diagrams, timelines, or other representations to show factors that have shaped a major technological system over time (e.g., energy, transportation, manufacturing, food production and distribution).] [*Assessment Boundary: Explanations do not need to include all possible factors or be quantitative.*]

d. **Construct arguments for and against the development of a new technology based on potential short and long term impacts (positive and negative) on the health of people and the natural environment.** [Clarification Statement: Students should consider the pros and cons of different new technologies such as maglev rail, genetically engineered crops, wearable computers, human space travel, and new energy systems that exploit renewable resources.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education*:

Science and Engineering Practices

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific knowledge, principles, and theories.
- Apply scientific reasoning to show why the data are adequate for the explanation or conclusion. (a),(c)
- Apply scientific knowledge to explain real-world examples or events and solve design problems. (a),(c)

Engaging in Argument from Evidence
Engaging in argument from evidence in 6–8 builds from K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world.
- Use oral and written arguments supported by empirical evidence and reasoning to support or refute an explanation for a phenomenon or a solution to a problem. (d)

Obtaining, Evaluating, and Communicating Information
Obtaining, evaluating, and communicating information in 6–8 builds on K–5 and progresses to evaluate the merit and validity of ideas and methods.
- Generate and communicate ideas and methods using scientific language and reasoning. (b)
- Gather, read, and explain information from appropriate sources and evaluate the credibility of the publication, authors, possible bias of the source, and methods used. (b)

Disciplinary Core Ideas

ETS2.A: Interdependence of Science, Engineering, and Technology
- Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. (a)
- In order to design better technologies, new science may need to be explored. (a)
- Technologies in turn extend the measurement, exploration, modeling, and computational capacity of scientific investigations. (a)

ETS2.B: Interactions of Engineering, Technology, Science, Society, and the Natural Environment
- All human activity draws on natural resources and has both short-term and long-term consequences, positive as well as negative for the health of both people and the natural environment. (b),(d)
- The uses of technology and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (c),(d)
- Thus technology use varies from region to region and over time. (c)
- Technologies that are beneficial for a certain purpose may later be seen to have impacts that were not foreseen. In such cases, new regulations on use or new technologies may be required. (b), (d)

Crosscutting Concepts

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Stability and Change
Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale. Small changes in one part of a system might cause large changes in another part. Stability might be disturbed either by sudden events or gradual changes that accumulate over time. Systems in dynamic equilibrium are stable due to a balance of feedback mechanisms.(b),(c),(d)

Connections to other DCIs in this grade-level: **MS.ESS-ESP, MS.ESS-WC, MS.ESS-HI, MS.LS-GDRO, MS.PS-WER, MS.ETS-ED**

Articulation of DCIs across grade-levels: **3.IF, 3.WCI, 4.LCT, 4.WAV, 5.ESI, 5.SSS, HS.ETS-ETSS**

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