HS-ETS1-1

Students who demonstrate understanding can:

Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Analyze complex real-world problems by specifying criteria and constraints for successful solutions.	**ETS1.A: Defining and Delimiting Engineering Problems** 6. Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. 7. Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.	------------------------ ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering, and Technology on Society and the Natural World** • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Assessment Targets

Assessment targets describe the focal knowledge, skills, and abilities for a given three-dimensional Performance Expectation. Please refer to the Introduction for a complete description of assessment targets.

Science and Engineering Subpractice(s)

Please refer to appendix A for a complete list of Science and Engineering Practices (SEP) subpractices. Note that the list in this section is not exhaustive.

1E.1 Ability to ask questions about a design problem or the designed world

1E.2 Ability to define a design problem

Science and Engineering Subpractice Assessment Targets

Please refer to appendix A for a complete list of SEP subpractice assessment targets. Note that the list in this section is not exhaustive.

1E.1.2 Ability to ask questions to identify, clarify or refine an engineering problem

1E.2.2 Ability to define a design problem to develop an object, process, or system that takes into consideration criteria and constraints that include science concepts among other considerations

1E.2.3 Ability to define a design problem for a process or system with interacting components that takes into consideration criteria, constraints, and stakeholder perspectives that include science conceptual understanding

Disciplinary Core Idea Assessment Targets

ETS1.A.6a Identify relevant physical principles that govern the functioning of a design solution

ETS1.A.6b Define engineering problem statements on the basis of background research on the nature of the problem and on pre-existing solutions

ETS1.A.6c Develop criteria for evaluating a design solution on the basis of the problem statement and constraints on viability

ETS1.A.7a Identify global challenges that share features across various societies and geographies

ETS1.A.7b Describe factors that impact how a global challenge manifests with local variations in local communities

ETS1.A.7c Refine an engineering problem statement in light of social wants and needs that vary from global to local scales

Crosscutting Concept Assessment Target(s)

Not applicable.

Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides a description of a global challenge that faces a local community:

- Selects or generates questions that could help determine criteria or constraints for design solutions (1E.1.2 and ETS1.A.6/7)

Task provides a description of a global challenge that faces a local community. It also provides a description of some of the wants and needs of that community:

- Selects or develops an appropriate engineering problem statement that considers how local wants and needs dictate criteria and constraints (1E.2.2 and ETS1.A.6/7)

Task provides a flawed problem definition for a global challenge that faces a local community. It also provides a description of some of the wants and needs of that community:

- Identifies aspects of the flawed problem definition that is inconsiderate of local wants and needs (1E.2.2 and ETS1.A.6/7)

- Generates a refined problem definition that is considerate of local wants and needs (1E.2.2 and ETS1.A.6/7)

Task provides a description of a global challenge that is manifesting in a particular fashion in a local community:

- Selects, from a list of possible problem definitions, the definition that best considers both physical and socially defined constraints/criteria on potential design solutions (1E.2.2 and ETS1.A.6/7)

Task provides a problem definition for a global challenge that faces a local community. It also provides a description of some of the wants and needs of various global and local stakeholders:

- Generates different variations on the problem definition that highlight the unique concerns of different stakeholder groups (e.g., an environmental group and a manufacturer of a product) (1E.2.3 and ETS1.A.7)

Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

- Relevant physical principles

- Cost of development

- Features of the local geography
- Differential features of local climate
- Trends in population growth or per-capita resource consumption
- Local and global trends in human behavior

Common Misconceptions

Note that the list in this section is not exhaustive.

- Design solutions should not consider human needs or behaviors.
- Global challenges are intractable or can only be solved by global action.
- Future trends that may affect the status of present criteria/constraints cannot be predicted.
- Design solutions should not consider multiple sources.

Additional Assessment Boundaries

None listed at this time.

Additional References

HS-ETS1-1 Evidence Statement

https://www.nextgenscience.org/sites/default/files/HS-ETS1-1_Evidence%20Statements%20Jan%202015.pdf

The *2016 Science Framework for California Public Schools Kindergarten through Grade 12 Appendix 1: Progression of the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts in Kindergarten through Grade 12*

https://www.cde.ca.gov/ci/sc/cf/documents/scifwappendix1.pdf

HS-ETS1-3

Students who demonstrate understanding can:

> **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.**

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories. • Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**ETS1.B: Developing Possible Solutions** 10. When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts.	------------------------- ***Connections to Engineering, Technology, and Applications of Science*** **Influence of Science, Engineering, and Technology on Society and the Natural World** • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

Assessment Targets

Assessment targets describe the focal knowledge, skills, and abilities for a given three-dimensional Performance Expectation. Please refer to the Introduction for a complete description of assessment targets.

Science and Engineering Subpractice(s)

Please refer to appendix A for a complete list of Science and Engineering Practices (SEP) subpractices. Note that the list in this section is not exhaustive.

6E.2 Ability to evaluate and/or refine solutions to design problems

Science and Engineering Subpractice Assessment Targets

Please refer to appendix A for a complete list of SEP subpractice assessment targets. Note that the list in this section is not exhaustive.

6E.2.2 Ability to evaluate and/or refine (optimize) design solutions based on scientific knowledge or evidence

6E.2.3 Ability to optimize performance of a design by prioritizing criteria, making tradeoffs, testing, revising, and re-testing

Disciplinary Core Idea Assessment Targets

ETS1.B.10a Identify three or more realistic criteria and two or more constraints such as cost, safety, and reliability as factors in determining an acceptable solution to a complex real-world problem

ETS1.B.10b Analyze and describe the strengths and weaknesses of the alternative proposed solution based on the prioritized criterion and constraints, including social, cultural, and environmental impacts

ETS1.B.10c Provide an evidence-based decision of which solution is optimum, based on prioritized criterion, analysis of strengths and weaknesses of each solution, and barriers to be overcome

ETS1.B.10d Identify any components of the complex real-world problem that may remain even as alternative solution is implemented

Crosscutting Concept Assessment Target(s)

Not applicable.

Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides descriptions of two or more alternative solutions to a complex real-world problem:

- Selects the best alternative solution from among multiple solutions based on their strengths and weaknesses (6E.2.2 and ETS1.B.10)
- Provides justification for the selection based on scientific principles and/or evidence (6E.2.2 and ETS1.B.10)

Task provides a description of a solution to a complex real-world problem:

- Identifies the scientific ideas, principles, or evidence that support the effectiveness of the proposed alternative solution (6E.2.3 and ETS1.B.10)
- Identifies possible unanticipated effects of the provided solution (6E.2.3 and ETS1.B.10)
- Evaluates the solution and correctly identifies how the proposed solution can be improved based on prioritized criterion, analysis of strengths and weaknesses of each improvement, and barriers to be overcome (6E.2.3 and ETS1.B.10)
- Identifies relevant constraints and social, cultural, and environmental impacts of the proposed solution (6E.2.3 and ETS1.B.10)

Environmental Principles and Concepts

- EP5: Decisions affecting resources and natural systems are based on a wide range of considerations and decision-making processes.

Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

- Pollution of air or water
- Quality of air or water
- Resource conservation
- Environmental accidents
- Bioengineering solutions
- Design of hazard-resilient building/structures

Common Misconceptions

Note that the list in this section is not exhaustive.

- Cost is always the main factor to consider in a design solution for a real world problem.
- There is an ideal solution for each problem.

Additional Assessment Boundaries

None listed at this time.

Additional References

HS-ETS1-3 Evidence Statement

https://www.nextgenscience.org/sites/default/files/HS-ETS1-3_Evidence%20Statements%20Jan%202015.pdf

Environmental Principles and Concepts http://californiaeei.org/abouteei/epc/

California Education and the Environment Initiative http://californiaeei.org/

The *2016 Science Framework for California Public Schools Kindergarten through Grade 12*

Appendix 1: Progression of the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts in Kindergarten through Grade 12

https://www.cde.ca.gov/ci/sc/cf/documents/scifwappendix1.pdf

Appendix 2: Connections to Environmental Principles and Concepts

https://www.cde.ca.gov/ci/sc/cf/documents/scifwappendix2.pdf

HS-ETS1-4

Students who demonstrate understanding can:

> **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.**

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems.	**ETS1.B: Developing Possible Solutions** 11. Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs.	**Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions — including energy, matter, and information flows — within and between systems at different scales.

Assessment Targets

Assessment targets describe the focal knowledge, skills, and abilities for a given three-dimensional Performance Expectation. Please refer to the Introduction for a complete description of assessment targets.

Science and Engineering Subpractice(s)

Please refer to appendix A for a complete list of Science and Engineering Practices (SEP) subpractices. Note that the list in this section is not exhaustive.

5.2 Ability to conduct mathematical and/or computational analyses

Science and Engineering Subpractice Assessment Targets

Please refer to appendix A for a complete list of SEP subpractice assessment targets. Note that the list in this section is not exhaustive.

5.2.1 Ability to use the results of computational models (e.g., graphical representation in a simulation) to identify the mathematical and/or computational representations to support a scientific explanation or a design solution

5.2.2 Ability to use computational models (e.g., simulations) to make predictions of a scientific phenomenon

5.2.3 Ability to use the results of computational models (e.g., simulations) to identify patterns in natural and/or design worlds

5.2.4 Ability to use critical mathematical skills to compare simulated effects in computational models to real world observations to identify limitations of computational models

Disciplinary Core Idea Assessment Targets

ETS1.B.11a Describe a complex real-world problem with criteria and constraints from a given computer simulation

ETS1.B.11b Identify the system being modeled by a computer simulation

ETS1.B.11c Identify the variables that can be changed in a computer simulation

ETS1.B.11d Identify the scientific principles used in a model of a complex real-world problem

ETS1.B.11e Select logical and realistic inputs for a computer simulation of a complex real-world problem

ETS1.B.11f Use a model to simulate the effects of different solutions, tradeoffs, criteria, and constraints

ETS1.B.11g Compare results from a model to expected results

ETS1.B.11h Identify possible consequences of a solution to a complex real-world problem

ETS1.B.11i Identify the limitations of a particular model

Crosscutting Concept Assessment Target(s)

CCC4 Use models (e.g., physical, mathematical, computer models) to simulate systems and interactions — including energy, matter, and information flows — within and between systems at different scales

Examples of Integration of Assessment Targets and Evidence

Note that the list in this section is not exhaustive.

Task provides a possible solution to a complex real-world problem and data generated from a computer simulation of the problem:

- Uses the data generated from the simulation to support or refute the design solution (5.2.1, ETS1.B.11, and CCC4)

Task provides a computer simulation of a complex real-world problem:

- Makes predictions for certain combinations of variable settings in the simulation related to a scientific phenomenon (5.2.2, ETS1.B.11, and CCC4)

Task provides data from one or more computer simulations of a complex real-world problem:

- Identifies patterns based on the simulation(s) (5.2.3, ETS1.B.11, and CCC4)

Task provides data from a computer simulation of a complex real-world problem:

- Uses statistical tools to analyze the data (5.2.4, ETS1.B.11, and CCC4)

- Identifies limitations of the simulation using statistical tools (5.2.4, ETS1.B.11, and CCC4)

Possible Phenomena or Contexts

Note that the list in this section is not exhaustive.

- Pollution (air or water)

- Water conservation

- Oil spills

- Air quality
- Endangered species
- Habitat and/or biodiversity loss due to development
- Bioengineering scenarios, including artificial limbs
- Sustainable design, such as green buildings and earthquake resilient buildings/structures

Common Misconceptions

None listed at this time.

Additional Assessment Boundaries

None listed at this time.

Additional References

HS-ETS1-4 Evidence Statement

https://www.nextgenscience.org/sites/default/files/HS-ETS1-4_Evidence%20Statements%20Jan%202015.pdf

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Appendix 1: Progression of the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts in Kindergarten through Grade 12

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