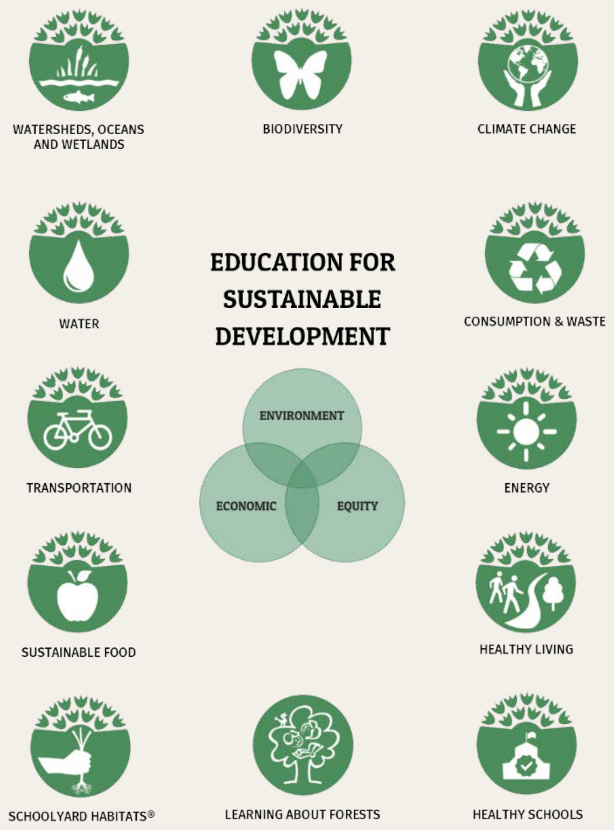
Pathways to Sustainability

Alignment to NGSS
Middle School: Engineering Design

By the time students reach middle school they should have had numerous experiences in engineering design. The goal for middle school students is to define problems more precisely, to conduct a more thorough process of choosing the best solution, and to optimize the final design.



Defining the problem with "precision" involves thinking more deeply than is expected in elementary school about the needs a problem is intended to address, or the goals a design is intended to reach. How will the end user decide whether or not the design is successful? Also at this level students are expected to consider not only the end user, but also the broader society and the environment. Every technological change is likely to have both intended and unintended effects. It is up to the designer to try to anticipate the effects it may have, and to behave responsibly in developing a new or improved technology. These considerations may take the form of either criteria or constraints on possible solutions.

Developing possible solutions does not explicitly address generating design ideas because students were expected to develop the capability in elementary school. The focus in middle school is on a two stage process of evaluating the different ideas that have been proposed by using a systematic method, such as a tradeoff matrix, to determine which solutions are most promising, and by testing different solutions, and then combining the best ideas into a new solution that may be better than any of the preliminary ideas.

Improving designs at the middle school level involves an iterative process in which students test the best design, analyze the results, modify the design accordingly, and then re-test and modify the design again. Students may go through this cycle two, three, or more times in order to reach the optimal (best possible) result.

Connections with other science disciplines help students develop these capabilities in various contexts. For example, in the life sciences students apply their engineering design capabilities to evaluate plans for maintaining biodiversity and ecosystem services (MS-LS2-5). In the physical sciences students define and solve problems involving a number of core ideas, including chemical processes that release or absorb energy (MS-PS1-6), Newton's Third Law of Motion (MS-PS2-1), and energy transfer (MS-PS3-3). In the Earth and space sciences students apply their engineering design capabilities to problems related the impacts of humans on Earth systems (MS-ESS3-3).

By the end of eighth grade students are expected to achieve all four performance expectations (MS-ETS1-1, MS-ETS1-2, MS-ETS1-3, and MS-ETS1-4) related to a single problem in order to understand the interrelated processes of engineering design. These include defining a problem by precisely specifying criteria and constraints for solutions as well as potential impacts on society and the natural environment, systematically evaluating alternative solutions, analyzing data from tests of different solutions and combining the best ideas into an improved solution, and developing a model and iteratively testing and improving it to reach an optimal solution. While the performance expectations shown in MS. Engineering Design couple particular practices with specific disciplinary core ideas, instructional decisions should include use of many practices that lead to the performance expectations.

Our program icons are used to denote pathway connections to the NGSS Performance Expectations and alignment to the Common Core State Standards, CCSS, English Language Arts, ELA and Mathematics.

Green STEM is an initiative of NWF's Eco-Schools USA program and is focused on identifying best practice in the STEM fields as it relates to environment-based learning. These elements include:

- Project, problem and place-based learning
- Utilizing the school, both inside and outside, as a learning laboratory
- Interdisciplinary approach
- Innovation space
- A commitment to stewardship
- An inclusive culture, where all students can learn, participate and take action

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 test 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.

CLIMATE CHANGE ENERGY HEALTHY LIVING

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Each Performance Expectation is more successfully accomplished by students who have numerous opportunities to engage in inquiry-based learning experiences and are utilizing the school as a learning laboratory. Students will be able to develop and use models with greater precision and understanding and have the ability to coherently communicate understanding using fact-based evidence.

Students who have played an integral role in making meaningful changes on their campus have the conceptual understanding needed to build new learning around the overarching concept, influencing science, engineering and technology on society and the natural world.

ENGINEERING DESIGN - CONTINUED

Driving Questions – Examples

- How can we, as coastal resiliency engineers, design solutions to local flooding using a combination of green, brown and gray infrastructure elements?
- How can we, materials scientists and engineers, develop a lightweight, space saving solution for schools to grow enough vegetables to support a 3 day a week salad bar for 1000 students and staff?
- How can we, as landscape architects, and with the support of National Wildlife Federation's ECHO program, design and install a natural outdoor play space for the neighboring preschool?
- How can we, as foresters and urban development managers, work with the school district to design and develop microforests, to support and/or address their economic, environmental and equity needs?
- How can we, as automotive engineers, develop a model car of the future that relies solely on renewable energy?

SCIENCE AND ENGINEERING PRACTICES	DISCIPLINARY CORE IDEAS	CROSSCUTTING CONCEPTS
• Asking Questions and Defining Problems • Developing and Using Models • Analyzing and Interpreting Data • Engaging in Argument from Evidence	**ETS1.A** Defining and Delimiting Engineering Problems **ETS1.B** Developing Possible Solutions **ETS1.C** Optimizing the Design Solution	Influence of Science, Engineering and Technology on Society and the Natural World

Connections to other DCIs to this grade band: **Life Science: MS-LS2**

Articulation of DCIs across grade-bands: **3-5.ETS1.A** (MS-ETS1-1) (MS-ETS1-2) (MS-ETS1-3); **3-5.ETS1.B** (MS-ETS1-2) (MS-ETS1-3) (MS-ETS1-4); **3-5.ETS1.C** (MS-ETS1-2) (MSETS1-3) (MS-ETS1-4); **HS.ETS1.A** (MS-ETS1-1) (MS-ETS1-2); **HS.ETS1.B** (MS-ETS1-1) (MS-ETS1-2) (MS-ETS1-3) (MS-ETS1-4); **HS.ETS1.C** (MS-ETS1-3) (MS-ETS1-4

ENGINEERING DESIGN - CONTINUED

Common Core State Standards Connections

ELA/Literacy

RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts. (MS-ETS1-1),(MS-ETS1-2),(MS-ETS1-3)

RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table). (MS-ETS1-3)

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic. (MS-ETS1-2),(MS-ETS1-3)

WHST.6-8.7 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. (MS-ETS1-1),(MS-ETS1-1)

WHST.6-8.8 Gather relevant information from multiple print and digital sources; assess the credibility of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources. (MS-ETS1-1)

WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research. (MS-ETS1-2)

SL.8.5 Include multimedia components and visual displays in presentations to clarify claims and findings and emphasize salient points. (MS-ETS1-4)

Mathematics

MP.2 Reason abstractly and quantitatively. (MS-ETS1-1) (MS-ETS1-2) (MS-ETS1-3) (MS-ETS1-4)

7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies. (MS-ETS1-1) (MS-ETS1-2) (MS-ETS1-3)