Engineering, Technology and the Application of Science Learning Progressions

Introduction

The New Jersey Student Learning Standards for Science (NJSLS-S) are built on the notion of learning as a developmental progression. They are designed to help children continually build on and revise their knowledge and abilities, starting from their curiosity about what they see around them and their initial conceptions about how the world works. The goal of science education is to guide their knowledge toward a more evidence - based and coherent view of the natural sciences and engineering (NGSS Lead States, 2013).

The fields of science and engineering are mutually supportive. New technology expands the reach of science. Science is utilized, in particular through the engineering design process. Engineers depend on the work of scientists to understand how different technologies work. Working at the interface of science, engineering, and society gives us deeper insights into local, national, and global issues (NRC, 2012, pp 201-203). The following tables provide readers with the progression of increasing complexity that each disciplinary core idea undergoes from kindergarten through grade 12. The tables provide invaluable insight into what the current focus of learning should be and provide insight into what the students learned before they came to your classroom, and what they will learn in a future course. The full range of information enables educators to scaffold learning experiences when there is unfinished learning from the previous year. It also provides a clear stopping point for current learning experiences. These progressions are derived from Chapter 8: Disciplinary Core Ideas—Engineering, Technology, and Applications of Science in *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (NRC, 2012)

It is important to note that the New Jersey Student Learning Standards for Science (NJSLS-S) show the integration of the three dimensions; science and engineering practices, disciplinary core ideas, and crosscutting concepts. This document in no way endorses separating the science and engineering practices from the other two dimensions.

Engineering, Technology, and Applications of Science

ETS1: Engineering Design

- ETS1.A: Defining and Delimiting an Engineering Problem
- ETS1.B: Developing Possible Solutions
- ETS1.C: Optimizing the Design Solution

Links Among Engineering, Technology, Science, and Society

- ETS2.A: Interdependence of Science, Engineering, and Technology
- ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World

Engineering Design (ETS1)

Overarching Question for ETS.1: How do engineers solve problems? (NRC, 2012, pp. 201- 214)

Component Ideas	Grades K – 2	Grades 3 – 5	Grades 6 – 8	Grades 9 – 12
ETS1.A: Defining and Delimiting Engineering Problems What is a design for? What are the criteria and constraints of a successful solution? (NRC, 2012, pp. 204-206)	• A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. (K-2-ETS1-1) • Asking questions, making observations, and gathering information are helpful in thinking about problems. (K-2-ETS1-1) • Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1)	• Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. (3-5-ETS1-1)	• 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. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions (MS-ETS1-1)	• 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. (HS-ETS1-1) • 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. (HS-ETS1-1)

Component Ideas	Grades K – 2	Grades 3 – 5	Grades 6 – 8	Grades 9 – 12
ETS1.B: Developing Possible Solutions What is the process for developing potential design solutions? (NRC, 2012, pp. 206-208)	• Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people. (K-2-ETS1-2)	• Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2) • At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2) • Tests are often designed to identify failure points or difficulties, which suggest the elements of the design that need to be improved. (3-5-ETS1-3)	• A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4) • There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3) • Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3) • Models of all kinds are important for testing solutions. (MS-ETS1-4)	• 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. (HS-ETS1-3) • 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. (HS-ETS1-4)

Links Among Engineering, Technology, Science, and Society (ETS2)

Overarching Question: How are engineering, technology, science, and society interconnected? (NRC, 2012, pp. 210-214)

Component Ideas	Grades K – 2	Grades 3 – 5	Grades 6 – 8	Grades 9 – 12
ETS2.A: Interdependence of Science, Engineering, And Technology What are the relationships among science, engineering, and technology? (NRC, 2012, pp. 2010-212)	• People encounter questions about the natural world every day. There are many types of tools produced by engineering that can be used in science to help answer these questions through observation or measurement. Observations and measurements are also used in engineering to help test and refine design ideas. (K-ESS3-2)	• Tools and instruments (e.g., rulers, balances, thermometers, graduated cylinders, telescopes, microscopes) are used in scientific exploration to gather data and help answer questions about the natural world. Engineering design can develop and improve such technologies. Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process. Knowledge of relevant scientific concepts and research findings is important in engineering. (3-PS2-4), (3-LS4-4), (4-PS4-3), (4-ESS3-1)	• 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. In order to design better technologies, new science may need to be explored (e.g., materials research prompted by desire for better batteries or solar cells, biological questions raised by medical problems). Technologies in turn extend the measurement, exploration, modeling, and computational capacity of scientific investigations. (MS-PS1-3), (MS-LS1-1), (MS-LS4-5), (MS-ESS1-3)	• Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. For example, developing a means for safely and securely disposing of nuclear waste will require the participation of engineers with specialties in nuclear engineering, transportation, construction, and safety; it is likely to require the contributions of scientists and other professionals as well from such diverse fields as physics, geology, economics, psychology, and sociology. (HS-PS4-5), (HS-ESS1-2), (HS-ESS2-3)

Component Ideas	Grades K – 2	Grades 3 – 5	Grades 6 – 8	Grades 9 – 12
ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World How do science, engineering, and the technologies that result from them affect the ways in which people live? How do they affect the natural world? (NRC, 2012, pp. 212-214)	• People depend on various technologies in their lives; human life would be very different without technology. Every human-made product is designed by applying some knowledge of the natural world and is built by using materials derived from the natural world, even when the materials are not themselves natural—for example, spoons made from refined metals. Thus, developing and using technology has impacts on the natural world. (K-ESS3-2), (1-PS4-4), (1-LS1-1), (2-PS1-2), (2-ESS2-1)	• Over time, people's needs and wants change, as do their demands for new and improved technologies. Engineers improve existing technologies or develop new ones to increase their benefits (e.g., better artificial limbs), to decrease known risks (e.g., seatbelts in cars), and to meet societal demands (e.g., cell phones). When new technologies become available, they can bring about changes in the way people live and interact with one another. (4-PS3-4), (4-ESS3-1), (4-ESS3-2), (3-5-ETS-1), (3-5-ETS-2)	• Over time, people's needs and wants change, as do their demands for new and improved technologies. Engineers improve existing technologies or develop new ones to increase their benefits (e.g., better artificial limbs), to decrease known risks (e.g., seatbelts in cars), and to meet societal demands (e.g., cell phones). When new technologies become available, they can bring about changes in the way people live and interact with one another. (MS-PS1-3), (MS-PS2-1), MS-PS4-3), (MS-LS2-5), (MS-LS4-5), (MS-ESS3-1), (MS-ESS2-3), (MS-ESS3-3), (MS-ESS3-4), (MS-ES1-1)	• Modern civilization depends on major technological systems, including those related to agriculture, health, water, energy, transportation, manufacturing, construction, and communications. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. Widespread adoption of technological innovations often depends on market forces or other societal demands, but it may also be subject to evaluation by scientists and engineers and to eventual government regulation. New technologies can have deep impacts on society and the environment, including some that were not anticipated or that may build up over time to a level that requires attention or mitigation. Analysis of costs, environmental impacts, and risks, as well as of expected benefits, is a critical aspect of decisions about technology use. (HS-PS3-3), (HS-PS4-2), HS-PS4-2), (HS-PS4-5), (HS-ESS2-2), (HS-ESS3-1), (HS-ESS3-2), (HS-ESS3-3), (HS-ESS3-4), (HS-ETS1-1), (HS-ETS1-3)

References

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