APPENDIX J – Science, Technology, Society and the Environment

The goal that all students should learn about the relationships among science, technology, and society (known by the acronym STS) came to prominence in the United Kingdom and the United States in the early 1980s. The individual most closely associated with this movement is Dr. Robert Yaeger, who has written extensively on the topic (e.g. Yaeger 1996). A study of state standards (Koehler et al. 2007) has shown that STS became common in state science education standards during the first decade of the millennium, with an increasing focus on environmental issues. Consequently, the core ideas that relate science and technology to society and the natural environment in Chapter 8 of *A Framework for K-12 Science Education* (NRC, 2012) are consistent with efforts in science education for the past three decades.

In the *Framework*

The *Framework* specifies two core ideas that relate science, technology, society and the environment: the interdependence of science, engineering and technology, and the influence of science, engineering and technology on society and the natural world.

The Interdependence of Science, Engineering, and Technology

The first core idea is that scientific inquiry, engineering design, and technological development are interdependent:

> *The fields of science and engineering are mutually supportive, and scientists and engineers often work together in teams, especially in fields at the borders of science and engineering. Advances in science offer new capabilities, new materials, or new understanding of processes that can be applied through engineering to produce advances in technology. Advances in technology, in turn, provide scientists with new capabilities to probe the natural world at larger or smaller scales; to record, manage, and analyze data; and to model ever more complex systems with greater precision. In addition, engineers' efforts to develop or improve technologies often raise new questions for scientists' investigations.* (NRC, 2012, p. 203)

The interdependence of science—with its resulting discoveries and principles—and engineering—with its resulting technologies—includes a number of ideas about how the fields of science and engineering interrelate. One is the idea that scientific discoveries enable engineers to do their work. For example, the discoveries of early explorers of electricity have enabled engineers to create a world linked by vast power grids that illuminate cities, enable communications, and accomplish thousands of other tasks. Engineering accomplishments also enable the work of scientists. For example, the development of the Hubble Space Telescope and very sensitive light sensors have made it possible for astronomers to discover our place in the universe, noticing previously unobserved planets and getting even further insight into the origin of stars and galaxies.

The vision projected by the *Framework* is that science and engineering continuously interact and move each other forward, as expressed in the following statement:

New insights from science often catalyze the emergence of new technologies and their applications, which are developed using engineering design. In turn, new technologies open opportunities for new scientific investigations. (NRC, p. 210)

This reflects the key roles both science and engineering play in driving each other forward in the research and development (R&D) cycle.

The Influence of Engineering, Technology, and Science on Society and the Natural World

The second core idea focuses on the more traditional STS theme, that scientific and technological advances can have a profound effect on society and the environment.

Together, advances in science, engineering, and technology can have—and indeed have had—profound effects on human society, in such areas as agriculture, transportation, health care, and communication, and on the natural environment. Each system can change significantly when new technologies are introduced, with both desired effects and unexpected outcomes. (NRC, 2012, p. 210).

This idea has two complementary parts. The first is that scientific discoveries and technological decisions affect human society and the natural environment. The second is that people make decisions for social and environmental reasons that ultimately guide the work of scientists and engineers. As expressed in the *Framework*:

From the earliest forms of agriculture to the latest technologies, all human activity has drawn on natural resources and has had both short- and long-term consequences, positive as well negative, for the health of both people and the natural environment. These consequences have grown stronger in recent human history. Society has changed dramatically, and human populations and longevity have increased, as advances in science and engineering have influenced the ways in which people interact with one another and with their surrounding natural environment.

Not only do science and engineering affect society; society's decisions (whether made through market forces or political processes) influence the work of scientists and engineers. These decisions sometimes establish goals and priorities for improving or replacing technologies; at other times they set limits, such as in regulating the extraction of raw materials or in setting allowable levels of pollution from mining, farming, and industry. (NRC, 2012, p. 212)

The first paragraph above refers to the central role that technological changes have had on society and the natural environment. For example, the development of new systems for growing, processing, and distributing food made possible the transition from widely dispersed hunter-gatherer groups to villages and eventually cities. While that change took place over thousands of years, in just the past generation we have seen vast growth in the size of cities along with the establishment of new global communications and trade networks. In 1960 the world population was 3 billion. Today it is more than 6 billion, and thanks to advances in medicine and public health, people are living longer. Additionally, the growth of industrialization around the world has increased the rate at which natural resources are being extracted, well beyond what might be expected from a doubling of world population alone.

The second paragraph emphasizes the limits to growth imposed by human society and by the environment, which has limited supplies of certain non-renewable resources. Together, these paragraphs point the way to new science education standards that will help today's children prepare for a world in which technological change, and the consequent impact on society and natural resources, will continue to accelerate.

Home and Community Connections to School Science for Student Diversity

While it has long been recognized that building home-school connections is important for the academic success of non-dominant student groups, in practice, this is rarely done in an effective manner. There is a perceived disconnect between the science practices taught in schools and the science supported in the homes and communities of non-dominant student groups. Recent research has identified resources and strengths in the family and home environments of non-dominant student groups (National Research Council, 2009). Students bring to the science classroom "funds of knowledge" that can serve as resources for academic learning when teachers find ways to validate and activate this prior knowledge (González, Moll, & Amanti, 2005). Several approaches build connections between home/community and school science: (1) increasing parent involvement in their children's science classroom and encouraging parents' roles as partners in science learning, (2) engaging students in defining problems and designing solutions of community projects in their neighborhoods (typically engineering), and (3) focusing on science learning in informal environments.

In the Next Generation Science Standards

There is a broad consensus that these two core ideas belong in the NGSS but a majority of state teams recommended that these ideas could best be illustrated through their connections to the natural science disciplines. There are a number of performance expectations that require students to demonstrate not only their understanding of a core idea in natural science, but also how that idea is supported by evidence derived from certain technological advances. The connection between these core ideas and specific performance expectations is shown in the crosscutting concept foundation box.

The following matrix summarizes how the two core ideas discussed in this chapter progress across the grade levels.

1. Interdependence of Science, Engineering, and Technology			
K-2 Connections Statements	**3-5 Connections Statements**	**6-8 Connections Statements**	**9-12 Connections Statements**
• Science and engineering involve the use of tools to observe and measure things.	• Science and technology support each other. • Tools and instruments are used to answer scientific questions, while scientific discoveries lead to the development of new technologies.	• 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. • Science and technology drive each other forward.	• 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.

2. Influence of Engineering, Technology, and Science on Society and the Natural World			
K-2 Connections Statements	**3-5 Connections Statements**	**6-8 Connections Statements**	**9-12 Connections Statements**
• Every human-made	• People's needs and	• All human activity draws on	• Modern civilization depends on

product is designed by applying some knowledge of the natural world and is built by using natural materials. • Taking natural materials to make things impacts the environment.	wants change over time, as do their demands for new and improved technologies. • Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. • When new technologies become available, they can bring about changes in the way people live and interact with one another.	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 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. • Technology use varies over time and from region to region.	major technological systems, such as agriculture, health, water, energy, transportation, manufacturing, construction, and communications. • Engineers continuously modify these systems to increase benefits while decreasing costs and risks. • 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.

Performance Expectations Related to the Interdependence of Science, Engineering, and Technology

	Physical Science	Life Science	Earth and Space Science	Engineering
K			K-ESS3-2	
1				
2				
3	3-PS2-4	3-LS4-3		
4	4-PS4-3		4-ESS3-1	
5				
6-8	MS-PS1-3	MS-LS1-1 MS-LS4-5	MS-ESS1-3	
9-12	HS-PS4-5		HS-ESS1-2 HS-ESS2-3 HS-ESS1-4	

Performance Expectations Related to the Influence of Engineering, and Technology and Science on Society and the Natural World

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

Conclusion

In the decades ahead, the continued growth of the world's population along with technological advances and scientific discoveries will continue to impact the lives of our students. Whether or not they choose to pursue careers in technical fields, they will be asked to make decisions that influence the development of technologies and the direction of scientific research that we cannot even imagine today. Consequently, it is important for teachers to engage their students in learning about the complex interactions among science, technology, society and the environment.

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