2014 Abridged

Technology and Engineering Literacy Framework

FOR THE 2014 NATIONAL ASSESSMENT OF EDUCATIONAL PROGRESS

NATIONAL ASSESSMENT GOVERNING BOARD

Introduction

We live in a world that is, to a large extent, shaped by technology: The computers and smart phones we use, the cars and planes we travel in, the homes and offices we inhabit; our food, clothes, entertainment, and medical care—all are created and driven by technology. Technology is also at the root of critical challenges we face as a society, such as the quest to link experts throughout the world, the search for sustainable energy, the ability to deal with global pandemics, and the development of environmentally friendly agriculture to feed a growing world population.

Until now, however, technology has not been a focus of instruction and assessment in our educational system, particularly at the elementary and secondary levels. Because of the growing importance of technology and engineering in the educational landscape, and to support America's ability to contribute to and compete in a global economy, the National Assessment Governing Board initiated development of the first national assessment in Technology and Engineering Literacy. Relating to national efforts in science, technology, engineering, and mathematics (STEM) fields, the NAEP Technology and Engineering Literacy assessment measures the "T" and "E" in STEM, augmenting longstanding NAEP assessments in science and mathematics.

NAEP Technology and Engineering Literacy (TEL) Assessment

The National Assessment of Educational Progress (NAEP), otherwise known as The Nation's Report Card, informs the public about the academic achievement of elementary and secondary students in the United States. Report cards communicate the findings of NAEP, a continuing and nationally representative measure of achievement in various subjects over time. For more than 35 years, NAEP has assessed achievement by testing samples of students most often in the fourth, eighth, and 12th grades. The results have become an important source of information on what U.S. students know and are able to do in a range of subject areas.

To create the new assessment, the National Assessment Governing Board sought a framework of technological literacy knowledge and skills that identifies the understandings and applications of technology principles that are important for all students. The framework defines "literacy" as the level of knowledge and competencies needed by all students and citizens. More than testing students for their ability to "do" engineering or produce technology, then, the assessment is designed to gauge how well students can apply their understanding of technology principles to real-life situations. At grade 4, for example, all students are expected to identify types of technologies in their world, design and test a simple model, explain how technologies can result in positive and negative effects, and use common technologies to achieve goals in school and in everyday life. By grade 12, students are expected to select and use a variety of tools and media to conduct research, evaluate how well a solution meets specified criteria, and develop a plan to address a complex global issue. To learn more, see a video clip ("Ecosystems") in the interactive framework of a sample scenario for grade 8 showing a student investigation of how organisms in an ecosystem are affected by a pollutant.

Technological literacy at grades 4, 8, and 12 is a pathway promoting further study and occupational pursuits. The Governing Board assembled a broad array of individuals and organizations to create a test of students' abilities to grasp and apply technology principles. The resulting framework is the culmination of a long, complex process that drew on the contributions of thousands of individuals and organizations including technology experts, engineers, teachers, researchers, business leaders, testing experts, and policymakers.

The 2014 NAEP Technology and Engineering Literacy Assessment will provide important results and information that can be used to determine whether our nation's students have the essential knowledge and skills needed in the technology and engineering areas. Policymakers, educators, and the public can use data from the initial assessments as tools for monitoring certain aspects of student achievement in technology and engineering literacy over time.

Definitions of Technology, Engineering, and Technology and Engineering Literacy

Any assessment of students' technology and engineering literacy must start with a clear idea of exactly what technology and engineering literacy means. That in turn requires clear definitions of technology and engineering.

Technology is any modification of the natural world done to fulfill human needs or desires.

This definition sees technology as encompassing the entire human-made world, from paper to the Internet. Technology also includes the entire infrastructure needed to design, manufacture, operate, and repair technological artifacts, from corporate headquarters and engineering schools to manufacturing plants and media outlets.

Engineering is a systematic and often iterative approach to designing objects, processes, and systems to meet human needs and wants.

This framework defines technology and engineering literacy in a broad fashion:

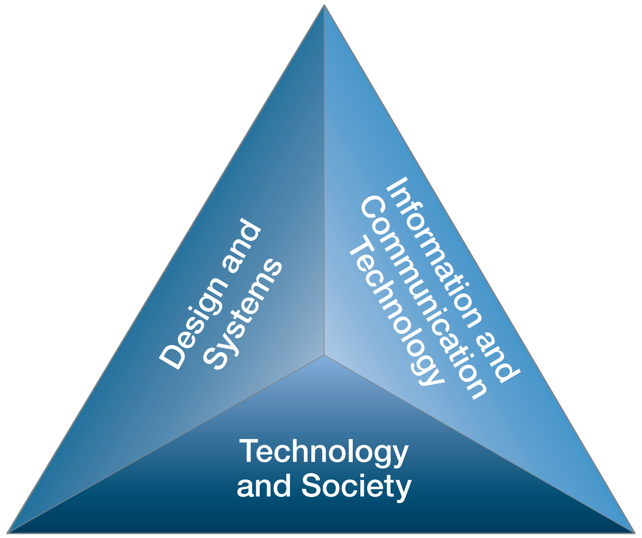
Technology and engineering literacy is the capacity to use, understand, and evaluate technology as well as to understand technological principles and strategies needed to develop solutions and achieve goals.

Thus—as with scientific, mathematical, and language literacy—technology and engineering literacy involves the mastery of a set of tools needed to participate intelligently and thoughtfully in society.

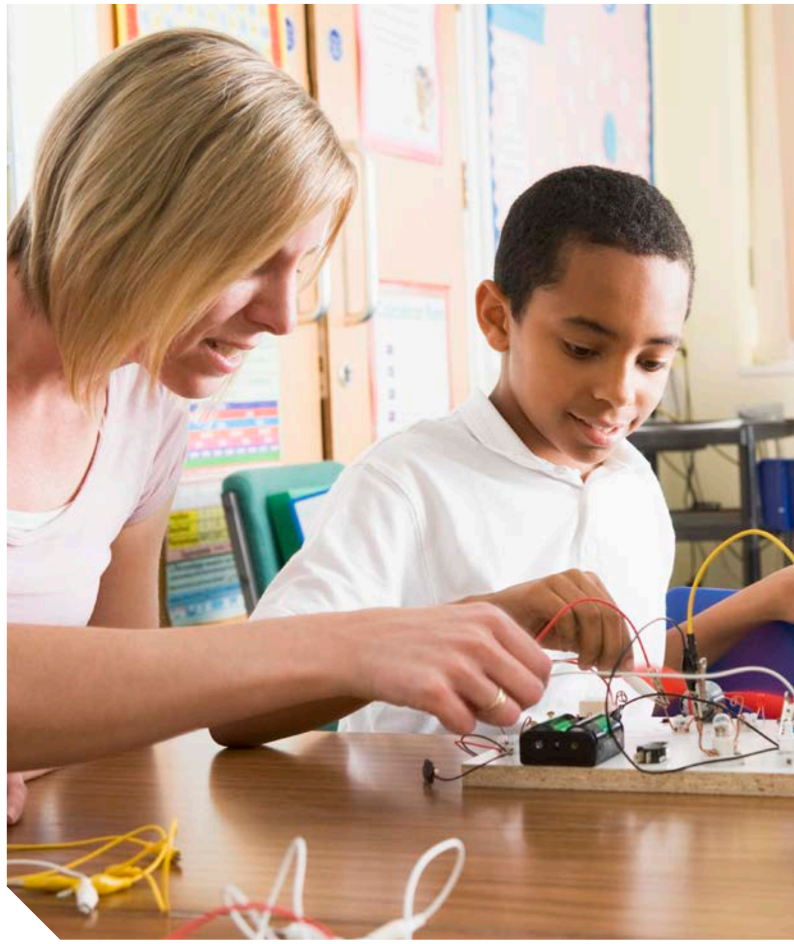
Three Areas of Technology and Engineering Literacy

Recognizing that it is not possible to assess every aspect of technology and engineering literacy, the TEL assessment framework targets the nature, processes, and uses of technology and engineering that are essential for 21st century citizens.

The assessment objectives are organized into three major areas: *Technology and Society; Design and Systems; and Information and Communication Technology (ICT).* Each broad category is further broken down into discrete areas to be assessed.



The interconnected relationship among these three major assessment areas can be illustrated as a three-sided pyramid in which each side supports the other two. For example, in order to address an issue related to technology and society, such as clean water, energy needs, or information research, a person who is literate in technology and engineering must understand technological systems and the engineering design process and be able to use various information and communication technologies to research the problem and develop possible solutions.



Area 1. Technology and Society

deals with the effects that technology has on society and on the natural world and with the sorts of ethical questions that arise from those effects.

The four sub-areas in which students are assessed include:

A. *Interaction of Technology and Humans* concerns the ways in which society drives the improvement and creation of new technologies and how technologies serve society as well as change it. **Fourth-graders** are expected to know that people's needs and desires determine which technologies are developed or improved. For example, cell phones were invented, produced, and sold because people found it useful to be able to communicate with others wherever they were. **Eighth-graders** are expected to understand how technologies and societies co-evolve over significant periods of time. For example, the need to move goods and people across distances prompted the development of a long series of transportation systems from horses and wagons to cars and airplanes. **By 12th grade,** students are expected to realize that the interplay between culture and technology is dynamic, with some changes happening slowly and others very rapidly. They should be able to use various principles of technology design—such as the concepts of trade-offs and unintended consequences—to analyze complex issues at the interface of technology and society and to consider the implications of alternative solutions.

B. *Effects of Technology on the Natural World* is about the positive and negative ways that technologies affect the natural world. **Fourth-graders** are expected to know that sometimes technology can cause environmental harm. For example, litter from food packages and plastic forks and spoons discarded on city streets can travel through storm drains to rivers and oceans where they can harm or kill wildlife. **Eighth-graders** are expected to recognize that technology and engineering decisions often involve weighing competing priorities, so that there are no perfect solutions. For example, dams built to control floods and produce electricity have left wilderness areas under water and affected the ability of certain fish to spawn. **By 12th grade,** students should have had a variety of experiences in which technologies were used to reduce the environmental impacts of other technologies, such as the use of environmental monitoring equipment.

C. *Effects of Technology on the World of Information and Knowledge* focuses on the rapidly expanding and changing ways that information and communication technologies enable data to be stored, organized, and accessed and on how those changes bring about benefits and challenges for society. **Fourth-graders** should know that information technology provides access to vast amounts of information, that it can also be used to modify and display data, and that communication technologies make it possible to communicate across great distances using writing, voice, and images. **Eighth-graders** should be aware of the rapid progress in development of ICT, should know how information technologies can be used to analyze, display, and communicate data, and should be able to collaborate with other students to develop and modify a knowledge product. **By 12th grade,** students should have a full grasp of the types of data, expertise, and knowledge available online and should be aware of intelligent information technologies and the uses of simulation and modeling.

D. *Ethics, Equity, and Responsibility* concerns the profound effects that technologies have on people, how those effects can widen or narrow disparities, and the responsibility that people have for the societal consequences of their technological decisions. **Fourth-graders** should recognize that tools and machines can be helpful or harmful. For example, cars are very helpful for going from one place to another quickly, but their use can lead to accidents in which people are seriously injured. **Eighth-graders** should be able to recognize that the potential for misusing technologies always exists and that the possible consequences of such misuse must be taken into account when making decisions. **By 12th grade,** students should be able to take into account both intended and unintended consequences in making technological decisions.

Area 2. Design and Systems covers the nature of technology, the engineering design process by which technologies are developed, and basic principles of dealing with everyday technologies, including maintenance and troubleshooting.

The four sub-areas in which students are assessed include:

A. *Nature of Technology* offers a broad definition of technology as consisting of all the products, processes, and systems created by people to meet human needs and desires. **Fourth-graders** are expected to distinguish natural and human-made materials, to be familiar with simple tools, and to recognize the vast array of technologies around them. **Eighth-graders** should know how technologies are created through invention and innovation, should recognize that sometimes a technology developed for one purpose is later adapted to other purposes, and should understand that technologies are constrained by natural laws. **By 12th grade,** students should have an in-depth understanding of the ways in which technology coevolves with science, mathematics, and other fields; should be able to apply the concept of trade-offs to resolve competing values; and should be able to identify the most important resources needed to carry out a task.

B. *Engineering Design* is a systematic approach to creating solutions to technological problems and finding ways to meet people's needs and desires. **Fourth-graders** should know that engineering design is a purposeful method of solving problems and achieving results. **Eighth-graders** should be able to carry out a full engineering design process to solve a problem of moderate difficulty. **By 12th grade,** students should be able to meet a complex challenge, weigh alternative solutions, and use the concept of trade-offs to balance competing values.

C. *Systems Thinking* is a way of thinking about devices and situations so as to better understand interactions among components, root causes of problems, and the consequences of various solutions. **Fourth-graders** should know that a system is a collection of interacting parts that make up a whole, that systems require energy, and that systems can be either living or non-living. **Eighth-graders** should be able to analyze a technological system in terms of goals, inputs, processes, outputs, feedback, and control, and they should be able to trace the life cycle of a product from raw materials to eventual disposal. **By 12th grade,** students should be aware that technological systems are the product of goal-directed designs and that the building blocks of any technology consist of systems that are embedded within larger technological, social, and environmental systems. They should also be aware that the stability of a system is influenced by all of its components, especially those in a feedback loop.

D. *Maintenance and Troubleshooting* is the set of methods used to prevent technological devices and systems from breaking down and to diagnose and fix them when they fail. **Fourth-graders** should know that it is important to care for tools and machines so they can be used when they are needed. Students should also know that if something does not work as expected, it is possible to find out what the problem is in order to decide if the item should be replaced or how to fix it. **Eighth-graders** should be familiar with the concept of maintenance and should understand that failure to maintain a device can lead to a malfunction. They should also be able to carry out troubleshooting, at least in simple situations. **By 12th grade,** students should know that many devices are designed to operate with high efficiency only if they are checked periodically and properly maintained. They should also have developed the capability to troubleshoot devices and systems, including those that they may have little experience with.

Area 3. Information and Communication Technology includes computers and software learning tools, networking systems and protocols, hand-held digital devices, and other technologies for accessing, creating, and communicating information and for facilitating creative expression.

The five sub-areas in which students are assessed include:

A. *Construction and Exchange of Ideas and Solutions* concerns an essential set of skills needed for using ICT and media to communicate ideas and collaborate with others. **Fourth-graders** should understand what is expected from members working as part of a team and should realize that teams are better than individuals at solving many kinds of problems. **Eighth-graders** should know that communicating always involves understanding the audience—the people for whom the message is intended. They should also be able to use feedback from others, and provide constructive criticism. **By 12th grade**, students are expected to have developed a number of effective strategies for collaborating with others and improving their teamwork. They should be able to synthesize information from different sources and communicate with multiple audiences.

B. *Information Research* includes the capability to employ technologies and media to find, evaluate, analyze, organize, and synthesize information from different sources. **Fourth-graders** should be aware of a number of digital and network tools that can be used for finding information, and they should be able to use these tools to collect, organize, and display data in response to specific questions and to help solve problems. **Eighth-graders** should be aware of digital and network tools and be able to use them efficiently. They should be aware that some of the information they retrieve may be distorted, exaggerated, or otherwise misrepresented, and they should be able to identify cases where the information is suspect. **By 12th grade**, students should be able to use advanced search methods and select the best digital tools and resources for various purposes. They should also be able to evaluate information for timeliness and accuracy.

C. *Investigation of Problems* concerns the use of information and communication technology to define and solve problems in core school subjects and in practical situations. **Fourth-graders** should be able to use a variety of information and communication technologies to investigate a local or otherwise familiar issue and to generate, present, and advocate for possible solutions. **Eighth-graders** should be able to use digital tools to identify and research a global issue and to identify and compare different possible solutions. **By 12th grade,** students should be able to use digital tools to research global issues and to fully investigate the pros and cons of different approaches. They should be able to design and conduct complex investigations in various subject areas using a variety of digital tools to collect, analyze, and display information and be able to explain the rationale for the approaches they used in designing the investigation as well as the implications of the results.

D. *Acknowledgement of Ideas and Information* involves respect for the intellectual property of others and knowledge of how to credit others' contributions appropriately, paying special attention to the misuse of information enabled by rapid technological advances. **Fourth-graders** should understand that it is permissible to use others' ideas as long as appropriate credit is given. They should also know that copyrighted materials cannot be shared freely. **Eighth-graders** should be aware of general principles concerning the use of other people's ideas and know that these principles are the basis for such things as school rules and federal laws governing such use. They should know about the limits of fair use of verbatim quotes and how to cite sources. **By 12th grade**, students should understand the fundamental reasons for intellectual property laws and should know acceptable practices for citing sources when incorporating ideas, quotes, and images into their own work.

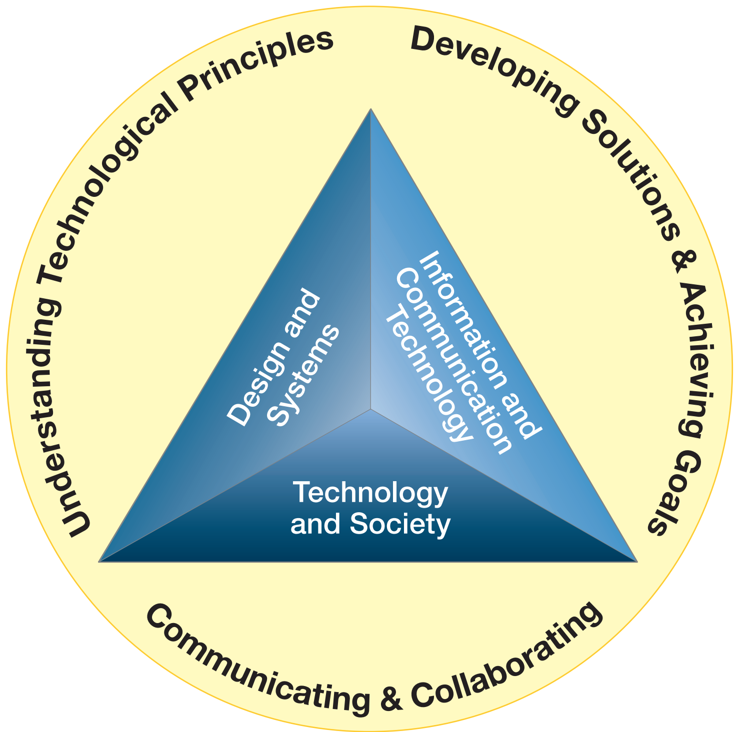
E. *Selection and Use of Digital Tools* includes both knowledge and skills for choosing appropriate tools and using a wide variety of electronic devices, including networked computing and communication technology and media. **Fourth-graders** should know that different digital tools have different purposes and they should also be able to use a variety of digital tools that are appropriate for their age level. **Eighth-graders** should be familiar with different types of digital tools and be able to move easily from one type of tool to another—for example, creating a document or image with one tool and then using a second tool to communicate the result to someone at a distant location. **By 12th grade,** students should be competent in the use of a broad variety of digital tools and be able to explain why some tools are more effective than others that were designed to serve the same purpose, based on the features of the individual tools.

Although these elements are central to the design of the NAEP Technology and Engineering Literacy Assessment, they are not sufficient to describe the kinds of reasoning to be expected from students, the context or subject matter that will be used to construct test items, or the overall shape of the entire assessment. The assessment targets and the sub-areas within each describing what students should be able to do foreshadow the cross-cutting practices—ways of thinking and reasoning—for which the TEL is designed.

Practices and Contexts for Technology and Engineering Literacy

In all three areas of technology and engineering literacy, students are expected to be able to apply particular ways of thinking and reasoning when approaching a problem, and they are expected to do so in various contexts.

The practices can be grouped into three broad categories: *Understanding Technological Principles; Developing Solutions and Achieving Goals; and Communicating and Collaborating.*



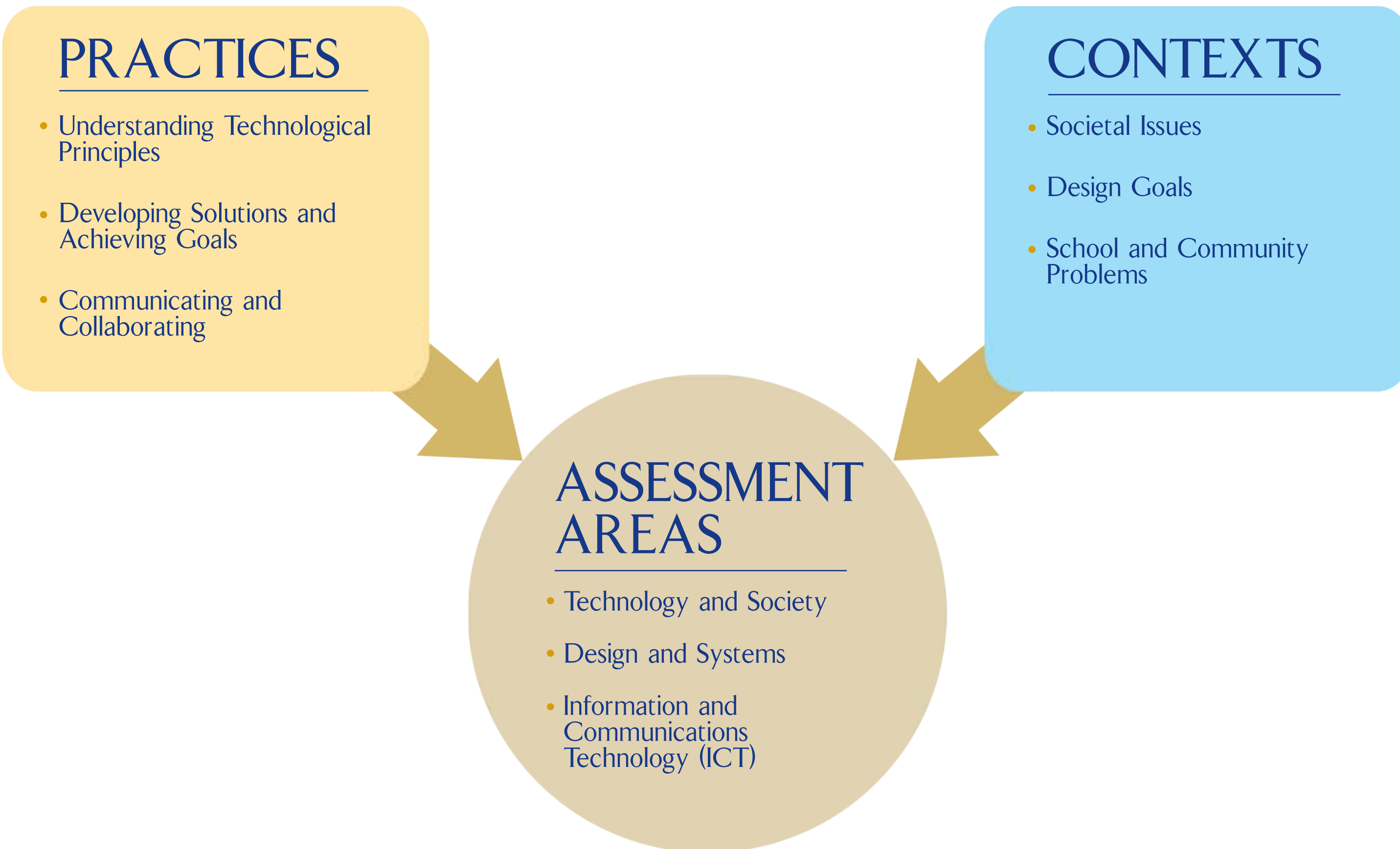
Understanding Technological Principles focuses on students' knowledge and understanding of technology and their capability to think and reason with that knowledge.

Developing Solutions and Achieving Goals refers to students' systematic application of technological knowledge, tools, and skills to address problems and achieve goals presented in societal, design, curriculum, and realistic contexts.

Communicating and Collaborating centers on students' capabilities to use contemporary technologies to communicate for a variety of purposes and in a variety of ways, working individually or in teams.

These practices are applied across all three major assessment areas. For example, communicating effectively and collaborating with others are necessary skills for understanding the effects of technology on the natural world, designing an engineering solution to a technological problem, and achieving a goal using information and communication technologies.

As crucial to the assessment as the practices are the **contexts**—the situations and types of problems in which assessment tasks and items will be set.



Elements of the NAEP Technology and Engineering Literacy Assessment

The practices expected of students are general, cross-cutting reasoning processes that students must use in order to show that they understand and can use their technological knowledge and skills. The contexts in which technology and engineering literacy tasks and items appear will include typical issues, problems, and goals that students might encounter in school or practical situations. Together, the assessment targets, practices, and contexts provide a structure for the generation of tasks and items.

Below are examples of the types of tasks and items that result when these three elements are combined. The table shows how the three practices—Understanding Technological Principles, Developing Solutions and Achieving Goals, and Communicating and Collaborating—can be used to classify the general types of thinking and reasoning intended by the assessment targets in the three major assessment areas of Technology and Society, Design and Systems, and Information and Communication Technology.

Classification of types of assessment targets in the three major assessment areas according to the practices for technology and engineering literacy

	Technology and Society	Design and Systems	Information and Communication Technology
Understanding Technological Principles	**Analyze** advantages and disadvantages of an existing technology **Explain** costs and benefits **Compare** effects of two technologies on individuals **Propose** solutions and alternatives **Predict** consequences of a technology **Select** among alternatives	**Describe** features of a system or process **Identify** examples of a system or process **Explain** the properties of different materials that determine which is suitable to use for a given application or product **Analyze** a need **Classify** the elements of a system	**Describe** features and functions of ICT tools **Explain** how parts of a whole interact **Analyze** and compare relevant features **Critique** a process or outcome **Evaluate** examples of effective resolution of opposing points of view **Justify** tool choice for a given purpose
Developing Solutions and Achieving Goals	**Select** appropriate technology to solve a societal problem **Develop** a plan to investigate an issue **Gather and Organize** data and information **Analyze and Compare** advantages and disadvantages of a proposed solution **Investigate** environmental and economic impacts of a proposed solution **Evaluate** trade-offs and impacts of a proposed solution	**Design and Build** a product using appropriate processes and materials **Develop** forecasting techniques **Construct and Test** a model or prototype **Produce** an alternative design or product **Evaluate** trade-offs **Determine** how to meet a need by choosing resources required to meet or satisfy that need **Plan** for durability **Troubleshoot** malfunctions	**Select and Use** appropriate tools to achieve a goal **Search** media and digital resources **Evaluate** credibility and solutions **Propose and Implement** strategies **Predict** outcomes of a proposed approach **Plan** research and presentations **Organize** data and information **Transform** from one representational form to another **Conduct** experiments using digital tools and simulations
Communicating and Collaborating	**Present** innovative, sustainable solutions **Represent** alternative analyses and solutions **Display** positive and negative consequences using data and media **Compose** a multimedia presentation **Produce** an accurate timeline of a technological development **Delegate** team assignments **Exchange** data and information with virtual peers and experts	**Display** design ideas using models and blueprints **Use** a variety of media and formats to communicate data, information, and ideas **Exhibit** design of a prototype **Represent** data in graphs, tables, and models **Organize, Monitor, and Evaluate** the effectiveness of design teams **Request** input from virtual experts and peers **Provide and Integrate** feedback	**Plan** delegation of tasks among team members **Provide and Integrate** feedback from virtual peers and experts to make changes in a presentation **Critique** presentations **Express** historical issues in a multimedia presentation **Argue** from an opposing point of view **Explain** to a specified audience how something works **Address** multiple audiences **Synthesize** data and points of view

Content and Design

To identify what students know and can do with regard to technology and engineering, the NAEP TEL framework calls for the assessment to be totally computer-based. In 2014 the NAEP TEL assessment will be conducted at grade 8 with a national sample of students in public and private schools. The assessment will include tasks and items sampled from the domain of technology and engineering literacy achievement identified by the intersection of the three major areas of technology and engineering literacy and the cross-cutting practices at grades 4, 8, and 12—grades that will participate in the TEL assessment in future years.

Allowing students to demonstrate the wide range of knowledge and skills detailed in the NAEP Technology and Engineering Literacy Assessment targets will require a departure from the typical assessment designs used in other NAEP content areas. Thus students will be asked to perform a variety of actions using a diverse set of tools in the process of solving problems and meeting goals within rich, complex scenarios that reflect realistic situations. Consequently, this assessment will rely primarily on scenario-based assessment sets that test students through their interaction with multimedia tasks that include conventional item types, such as selected response items, and also monitor student actions as they manipulate components of the systems and models that are presented as part of the task.

Because of their capability to replicate authentic situations examinees may encounter in their lives, scenarios have the potential to provide a level of authenticity other types of assessment tasks cannot provide. At the same time, the choice to use these complex tasks reduces the number of measures that can be included in any one test and causes many of the measures to be interdependent because they are related to the same scenario. To counteract this interdependency and ensure reliability, the NAEP assessment of technology and engineering literacy will also include sets of discrete items that produce independent measures.

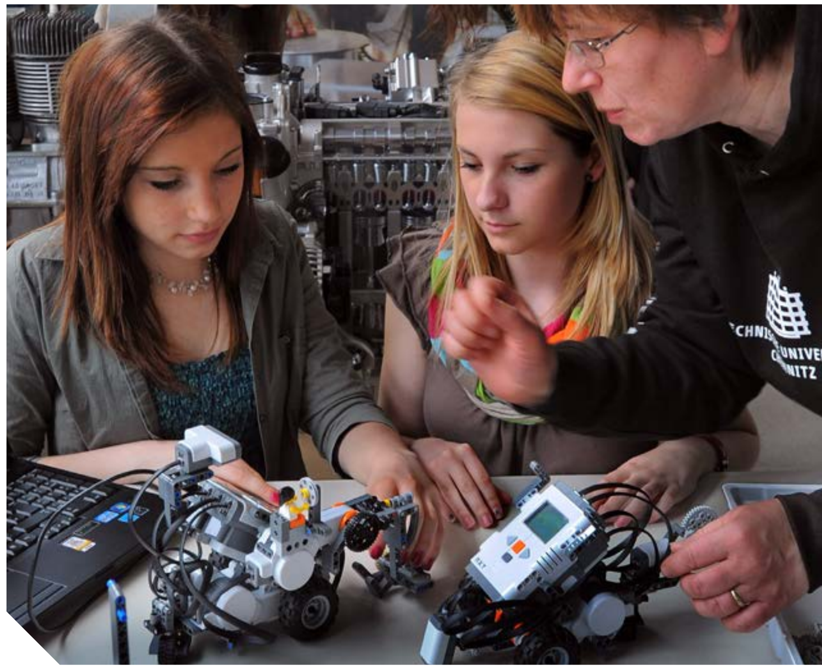
Scenario-Based Assessment Sets

There will be two types of scenario-based assessment sets, one long and one short. The long scenarios will take students approximately 25 minutes. The short scenarios will take students about 12 to 15 minutes to respond. The two types of scenarios have common characteristics, but they differ in the complexity of the scenario and the number of embedded assessment tasks and items to which a student is asked to respond.

A set of sample video clips demonstrates the types of interactivity and functionality of tools that students might be expected to use as they respond to short and long scenarios that will be developed for the Technology and Engineering Literacy Assessment.

Discrete Item Sets

Discrete item sets will include conventional selected response items and short constructed response items. The discrete item sets will comprise approximately 10-15 stand-alone items in either selected or constructed response format to be completed within a 25-minute block. Each discrete item would provide a stimulus that presents enough information to answer the particular question posed in the stem of the item. Items in discrete sets will be selected response items (e.g., multiple choice) or short constructed response items in which a student writes a text-based response.

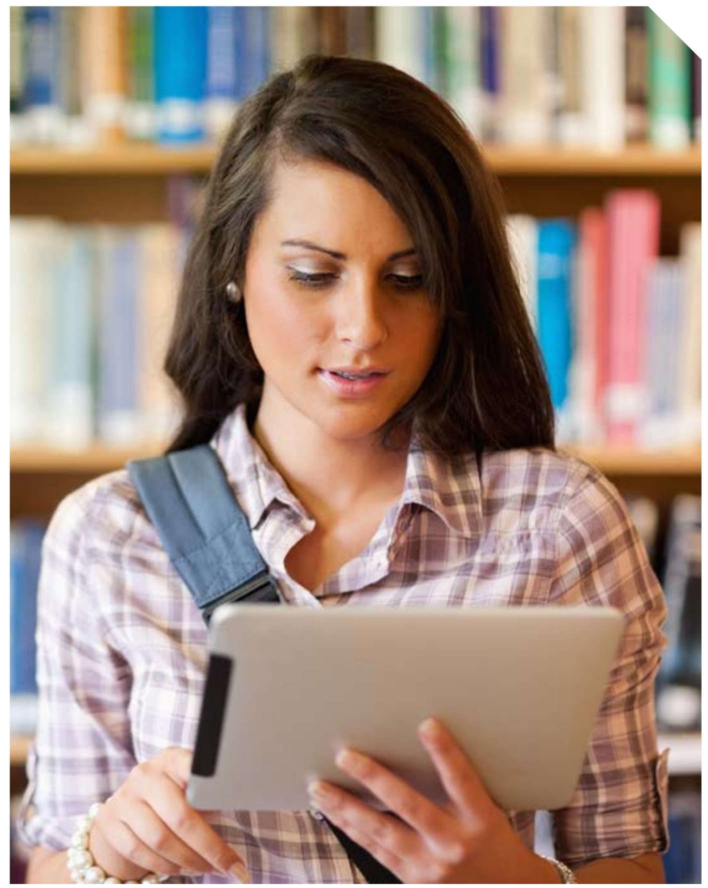


Background Variables

Background data on students, teachers, and schools are needed to fulfill the statutory requirement that NAEP include information, whenever feasible, for various subgroups of students at the national level including gender, race/ethnicity, eligibility for free or reduced-price lunch, English language learners, and students with disabilities. Therefore, students, teachers, and school administrators participating in NAEP are asked to respond to questionnaires designed to gather demographic information. Information is also gathered from non-NAEP sources, such as state, district, or school records. For the 2014 NAEP Technology and Engineering Literacy Assessment, only student and school information will be collected as many students will not have taken a separate course in technology and engineering literacy taught by a specific teacher.

In addition to demographic information, background questionnaires include questions about variables related to opportunities to learn and achievement in technology and engineering literacy. The variables are selected to be of topical interest, to be timely, and to be directly related to academic achievement and current trends and issues in technology and engineering literacy. Questions do not solicit information about personal topics or information irrelevant to the collection of data on technology and engineering literacy achievement.

Achievement Levels



The Governing Board uses student achievement levels of *Basic, Proficient,* and *Advanced* to report results of NAEP assessments. The achievement levels represent an informed judgment of “how good is good enough” in the various subjects that are assessed. Technology and Engineering Literacy achievement levels specific to the 2014 NAEP Technology and Engineering Literacy Framework will be developed to elaborate the generic policy definitions of *Basic, Proficient,* and *Advanced* achievement. Preliminary achievement level definitions have been developed for each of the three areas to be reported separately in the assessment and they will be used to guide item development and initial stages of standard setting for the 2014 NAEP Technology and Engineering Literacy Assessment.

The preliminary achievement level definitions will be revised when actual student responses have been collected and analyzed. The Governing Board will convene panels of experts to examine the preliminary achievement level definitions and to recommend final achievement level definitions for each grade level.

Conclusion

For generations students have been taught about technology and have been instructed in the use of various technological devices, but there has been no way to know exactly what students understand about technologies and their effective uses. The exploding growth in the world of technology led the Governing Board to sponsor the development of a framework for a National Assessment of Technology and Engineering Literacy. The Governing Board hopes that this TEL Framework will serve as a significant national measure of what students know and can do in technology and engineering, and support improvements in student achievement.

To view the complete Technology and Engineering Literacy Framework for the 2014 NAEP, or to view an interactive version of the framework, please visit http://nagb.org/publications/frameworks.htm or call us at 202.357.6938.

The National Assessment Governing Board is an independent, bipartisan board whose members include governors, state legislators, local and state school officials, educators, business representatives, and members of the general public. Congress created the 26-member Governing Board in 1988 to set policy for the National Assessment of Educational Progress (NAEP).

For more information on the National Assessment Governing Board, please visit www.nagb.org or call us at 202-357-6938.