VIRGINIA DEPARTMENT OF EDUCATION

BRIEFING

STANDARDS FOR TECHNOLOGICAL LITERACY AND PROJECT LEAD THE WAY

PRESENTED TO

JOINT SUBCOMMITTEE STUDYING SCIENCE, MATHEMATICS, AND TECHNOLOGY EDUCATION

OCTOBER 10, 2006

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PART I: Standards for Technological Literacy

Development of the Standards

- The *Standards for Technological Literacy: Content for the Study of Technology* were developed as the result of both National Science Foundation (NSF) and National Aeronautics and Space Administration (NASA) grants administered by the International Technology Education Association (ITEA) and its Technology for All Americans Project.

- The standards were released in 2001 after rigorous evaluation by the National Research Council's Standards Review Committee, involving the National Academy of Engineering Special Review Committee.

- The standards define what students should know and be able to do in order to be technologically literate, enabling people to develop knowledge and abilities about human innovation in order to help our nation maintain and sustain economic progress.

- *Standards for Technological Literacy* establish requirements and benchmarks for all K-12 students, with 20 broadly stated standards that specify what every student should learn about technology. As a result, a technologically literate person understands what technology is, how it is created, how it shapes society, and is in turn shaped by society.

Listing of the Technology Content Standards

- Nature of Technology - Students will develop an understanding of:
  1. Characteristics and Scope of Technology
  2. The Core Concepts of Technology
  3. Relationships Among Technologies and the Connections Between Technology and Other Fields

- Technology and Society – Students will develop an understanding of:
  4. The Cultural, Social, Economic, and Political Effects of Technology

5. The Effects of Technology on the Environment
6. The Role of Society in the Development and Use of Technology
7. The Influence of Technology on History

- Design – Students will develop an understanding of:
    8. The Attributes of Design
    9. Engineering Design
    10. The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

- Abilities for a Technological World – Students will develop the abilities to:
    11. Apply Design Processes
    12. Use and Maintain Technological Products and Systems
    13. Assess the Impact of Products and Systems

- The Designed World – Students will develop an understanding of and be able to select and use:
    14. Medical Technologies
    15. Agriculture and Related Bio Technologies
    16. Energy and Power Technologies
    17. Information and Communication Technologies
    18. Transportation Technologies
    19. Manufacturing Technologies
    20. Construction Technologies

- Standards-based Technology Education is designed to engage student interest through hands-on/minds-on exploration of the designed world of the society in which they live. The value of design and modeling helps students develop spatial and visualization abilities critical to success.

- As students learn about the world around them, they discover relevance of other aspects of education as they use them to research, design, and implement solutions to technological challenges and issues.

- Students learn about the unique core concepts of technology; that technology involves resources, systems, processes, and controls, as well as optimization and trade-off as things are designed. They develop systems thinking as well as confidence in design, problem solving, and use of systems.

- As students study technology, they progress from awareness and understanding of interactions of the designed world to the development of abilities to apply the design process, and use, maintain, and assess the impacts of products and systems. Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.

- Engaging in the process of learning about the pervasive nature of technology, its history, how it effects society and the environment, and in turn is driven by cultural, economic, and political issues, students are led to identify their own talents and interests. The result is a student who is well grounded in the technological nature of our world and ready to make decisions regarding further study in any field.

Description of Standards-based Experiences by Grade Level:

- **Grades K-5 -** In the elementary school, students will:

  - ➢ Learn that people create technology as they create tools and products from materials. Technology and nature are different, both having systems. (The Nature of Technology)

  - ➢ Learn that technology can be helpful or harmful, the effects of technology on the environment, the importance of renewable resources, and the influence of technology on history as people expanded their needs from food, clothing, and protection to more advanced needs and wants of society. (Technology and Society)

  - ➢ Learn that design is a creative process that everyone can be involved in, with specific requirements and the engineering design process to guide them. They begin to troubleshoot and experiment as they learn about invention and innovation. (Design)

- Begin to communicate their thoughts about the challenges they are given through drawing, modeling, and words. (Abilities for a Technological World)

- Recognize that the designed world is all around them in the forms of medicine, agriculture, energy and power, information and communication, transportation, manufacturing, and construction technologies. (The Designed World)

- **Grades 6-8** – In the middle school, students will:

  - Learn how people creatively use resources to develop systems and products that make things easier and increase the quality of life. They learn the parts of systems and about interaction among them, as well as the interrelations of technologies and knowledge of other fields of study. (The Nature of Technology)

  - Learn about the impacts and consequences of technology including ethical issues and influences on economy, politics and culture such as environmental vs. economic concerns. They learn about specialization of labor, evolution of techniques, measurement and resources, and how technological and scientific advances enhance each other. (Technology and Society)

  - Learn how design leads to useful products and systems, how brainstorming can increase the potential of a group, and how modeling, testing, and evaluating designs lead to modification. They learn how to troubleshoot systems to solve problems. (Design)

  - Learn how to apply the design process, identify criteria and constraints, and make, test, and evaluate a product or system. They use information to understand how things work, while safely using tools to diagnose, adjust, and repair systems. They design and use instruments to collect and interpret data to identify trends, as well as evaluate and interpret the accuracy of information. (Abilities for a Technological World)

  - Learn how inventions and innovations affect the areas of the designed world from medical and biotechnology through transportation, manufacturing, and construction systems by designing and producing systems. They learn about energy as the capacity to do work, how it is converted from one form to another, and how efficiency and conservation of energy affect systems. They learn how information and communication systems use energy to encode, transmit, and receive information as they use these systems to design messages. (The Designed World)

- **Grades 9-12** – In high school, students will:

  - Learn that technology's nature and development are functions of societal needs and wants, with the rate of development and diffusion increasing rapidly. They continue to explore by design and use of various systems while applying their academic skills to technological challenges. Invention and innovation are approached from the perspective of transfer of knowledge, patents, and protection of intellectual property. (The Nature of Technology)

  - Continue to study the effects of society on technology and that of technology on societies and the environment. The history of technology and its effects are explored in detail to help students learn to make appropriate decisions about development and consequences of introducing new technologies. (Technology and Society)

  - Continue to use the design process and principles, learning to clarify the issues and requirements involved in challenges, develop prototypes, and incorporate factors of engineering design. They apply the design process, documenting and communicating processes and procedures. They operate, troubleshoot, and maintain systems while synthesizing data to draw conclusions and utilize assessment techniques. (Design)

  - Begin to study various areas of the designed world that they find relevant and personally interesting. They may choose multiple aspects of the designed world in which to apply their prior knowledge and gain comprehension of factors that will lead to decisions for further study. (Abilities for a Technological World)

- **Standards Assessment:**

  - The *Standards for Technological Literacy* provide a systematic, multi-step process of collecting evidence on student learning, understanding, and abilities and requires measuring critical thinking and transfer of knowledge to real world situations.

  - Technology assessment of student achievement incorporates multiple standards to highlight interrelationships among technologies and the connections between technology and other disciplines. As a result, students are:

    - Required to perform complex tasks using what they have learned and appropriate technological resources
    - Assessed on their ability to use appropriate technology, science, and mathematics principles
    - Assessed on their ability to be creative in designing technological solutions
    - Assessed on the rigor of their methodology and the quality of the questions they pursue
    - Required to demonstrate their knowledge and abilities by creating a response or product that resembles practical experience

  - Student assessment must reflect the active, dynamic nature of the study of technology and the manner in which people draw upon and exercise knowledge and abilities acquired through experience.

Supporting Standards Documents

- In addition to the development of the *Standards for Technological Literary*, the following standards-based publications provide details for implementation and assessment of student performance:

  - Technological Literacy for All: A Rationale and Structure for the Study of Technology
  - Realizing Excellence: Structuring Technology Programs
  - Measuring Progress: Assessing Students for Technological Literacy
  - Planning Learning: Developing Technology Curricula
  - Developing Professionals: Preparing Technology Teachers

PART II: Project Lead The Way

- Project Lead The Way (PLTW) is a not-for-profit organization that partners with public schools, organizations in the private sector and higher education institutions to increase the number and quality of engineers graduating from the nation's education system.

- The PLTW curriculum is a four-year, flexible sequence of pre-engineering courses that, when combined with college preparatory mathematics and science courses in high school, introduces students to the scope, rigor and discipline of engineering and engineering technology prior to entering college.

- The courses are Principles of Engineering, Introduction to Engineering Design, Digital Electronics, Computer Integrated Manufacturing, Civil Engineering and Architecture, and Engineering Design and Development.

- Approximately 1,700 schools in 47 states and the District of Columbia have adopted PLTW's curriculum. Currently, 24 schools offer PLTW courses in Virginia.

- High school teachers in PLTW schools undergo an intensive two-week graduate level training program for each course.

- Ongoing professional development for both teachers and counselors is also an important component of the program.

- PLTW secondary school graduates are expected to:
    - Understand technology as a tool for problem solving
    - Have a broad-based understanding of the underlying methodology of science processes
    - Be well prepared for the rigorous college curriculum
    - Understand, apply, analyze and design technological systems
    - Select an appropriate technology system for a task and apply it
    - Understand the principles of mathematics
    - Demonstrate effective communication of information and solutions

  - Possess the skills necessary to work in teams effectively

- PLTW recommends that the program should be offered to the top 80 percent* of students in a school which includes students who are:

  - In the top 10 percent of their class
  - Good in mathematics and science
  - Interested in being engineers or technologists
  - Good in art and design
  - Underachievers who might get hooked by a high tech, hands-on class
  - Struggling students who learn best by "doing"

  * The 80 percent may vary from school to school. Students who would *not* be appropriately placed in the PLTW high school program are those who are taking certain mathematics courses such as General Mathematics and Consumer Mathematics, exhibiting weak mathematics skills, demonstrating little interest in science, or who are enrolling in alternative, remedial educational programs.

- College Credit: Once a high school in the PLTW Network of Schools is certified within two years of implementation, students are eligible to apply for the Exemplary Student Recognition Program, which offers transcripted college credit or other forms of recognition at over twenty national affiliate colleges and universities.

  - Students in certified schools who earn a "B" average or higher in their PLTW courses and score 70 percent or higher on the PLTW college credit exam are eligible to apply for college credit or recognition, depending on the requirements of the affiliates.

- PLTW requires that the school division sign a School Agreement affirming that all high schools will be certified by the second year in the program and re-certified every five years after.

  - This process requires schools to demonstrate that they meet PLTW's quality standards in professional development of teachers and counselors; the implementation of curriculum using required equipment and software; the formation of a Partnership Team, and several other requirements.

- School Divisions That Offer Project Lead The Way

Arlington County	Arlington Career Center Swanson Middle School Wakefield High School Washington & Lee High School
Clarke County	Clarke County High School
Fluvanna County	Fluvanna County High School
Gloucester County	Gloucester County High School Page Middle School Peasley Middle School
Hampton City	Phoebus High School Thomas Eaton Middle School
Henry County	Bassett High School Magna Vista High School
Madison County	Madison County High School
Montgomery County	Blacksburg High School
Pittsylvania County	Chatham High School
Prince William County	Woodbridge Senior High School
Richmond City	Chandler Middle School John F. Kennedy High School Martin Luther King, Jr. Middle School Fred D. Thompson Middle School
Russell County	Russell County Career & Technology Center
Smyth County	Smyth County Career & Technical Center
Williamsburg-James City County	Jamestown High School

- Old Dominion University serves as the Virginia PLTW university affiliate. As the state affiliate, ODU is responsible for providing in-depth graduate level summer training to prepare teachers to offer each approved PLTW course. Teachers may also attend other universities in the network of affiliate universities across the country.

- PLTW is currently developing two new instructional programs in the areas of Biotechnical Engineering and Aerospace Engineering.

Description of the Middle School Program (Gateway To Technology)

Gateway To Technology consists of five independent units that should be taught in conjunction with a rigorous academic curriculum. The units are designed to challenge and engage the exploratory minds of middle school students. Each nine–week unit contains performance objectives and suggested assessment methods. The five units are:

<u>Design and Modeling</u> **-** This unit uses solid modeling (a sophisticated mathematical technique for representing solid objects) to introduce students to the design process. Using this design approach, students understand how solid modeling has influenced their lives. Students also learn sketching techniques and use descriptive geometry as a component of design, measurement, and computer modeling. Using design briefs or abstracts, students create models and documentation to solve problems.

<u>The Magic of Electrons</u> **-** Through hands-on projects, students explore the science of electricity, the movement of atoms, circuit design, and sensing devices. Students acquire knowledge and skills in basic circuitry design and explore the impact of electricity on our lives.

<u>The Science of Technology</u> **-** This unit traces how science has affected technology throughout history. Students learn about the mechanics of motion, the conversion of energy, and the use of science to improve communication.

<u>Automation and Robotics</u> **-** Students trace the history and development of automation and robotics. They learn about structures, energy transfer, machine automation, and computer control systems. Students acquire knowledge and skills in engineering problem solving and explore requirements for careers in engineering.

<u>Flight and Space</u> **-** The purpose of this unit is to introduce the student to aeronautics, space, and the use of design used to help make aerospace engineering an important field. They learn about Newton's Laws of Motion, forces, rockets, propulsion, and what makes things fly. Students acquire and apply knowledge and skills in engineering problem solving and explore the many aspects of aerospace engineering.

Description of High School Courses (Pathway to Engineering)

- Principles of Engineering - A course that helps students understand the field of engineering/engineering technology. Exploring various technology systems and manufacturing processes helps students learn how engineers and technicians use mathematics, science and technology in an engineering problem solving process to benefit people. The course also includes concerns about social and political consequences of technological change.

- Digital Electronics - A course in applied logic that encompasses the application of electronic circuits and devices. Computer simulation software is used to design and test digital circuitry prior to the actual construction of circuits and devices.

- Introduction to Engineering Design - A course that teaches problem-solving skills using a design development process. Models of product solutions are created, analyzed and communicated using solid modeling computer design software. In New York State, the course is called Design and Drawing for Production and follows the syllabus developed by the State Education Department.

- Computer Integrated Manufacturing - A course that applies principles of robotics and automation. The course builds on computer solid modeling skills developed in Introduction to Engineering Design, and Design and Drawing for Production. Students use computer numerical control equipment to produce actual models of their three-dimensional designs. Fundamental concepts of robotics used in automated manufacturing, and design analysis are included.

- Civil Engineering and Architecture - This course provides an overview of the fields of Civil Engineering and Architecture, while emphasizing the interrelationship and dependence of both fields on each other. Students use state of the art software to solve real world problems and communicate solutions to hands-on projects and activities. This course covers topics such as: The Roles of Civil Engineers and Architects, Project Planning, Site Planning, Building Design, and Project Documentation and Presentation.

- Engineering Design and Development - An engineering research course in which students work in teams to research, design and construct a solution to an open-ended engineering problem. Students apply principles developed in the four preceding courses and are guided by a community mentor. They must present progress reports, submit a final written report and defend their solutions to a panel of outside reviewers at the end of the school year.

- Aerospace Engineering - Through hands-on engineering projects developed with NASA, students learn about aerodynamics, astronautics, space-life sciences, and systems engineering (which includes the study of intelligent vehicles like the Mars rovers Spirit and Opportunity).

- Biotechnical Engineering - Relevant projects from the diverse fields of bio-technology, bio-engineering, bio-medical engineering, and bio-molecular engineering enable students to apply and concurrently develop secondary-level knowledge and skills in biology, physics, technology, and mathematics.

Sample Student Schedule

English 9 Social Studies Mathematics Science Foreign Language **Principles of Engineering** Physical Education	English 10 Social Studies Mathematics Science Foreign Language **Principles of Engineering** Physical Education
English 11 Social Studies Mathematics Science **Digital Electronics (or one of the following: Computer Integrated Manufacturing, Civil Engineering and Architecture, Biotechnical Engineering, Aerospace Engineering)** Physical Education	English 12 Social Studies Mathematics Science **Engineering Design and Development** Health Physical Education

PLTW Program Evaluation

Initial research findings on the effectiveness of the Project Lead The Way program include:

A study by the Southern Regional Education Board (2005) where Project Lead The Way students**:**

- Achieved significantly higher in mathematics than students in comparable career and technical programs.
- Achieved significantly higher than all students in career and technical programs in mathematics, science and reading.
- Completed significantly more, higher level mathematics and science courses.

A study by True Outcomes of York, Pennsylvania (2005) showed that:

- 80 percent of seniors in Project Lead The Way planned on attending college or community college compared to 65 percent nationwide.
- 54 percent planned to enroll in engineering or engineering technology compared to 10 percent nationally.
- 19 percent planned on attending community college or Technical School.
- Overall schools offering PLTW were representative of their state's population.
- Minority student participation met or exceeded the proportion of Bachelor's Degrees awarded in Engineering in 2004 to minority students by race.
- The representation of Hispanics and African-Americans in PLTW courses was double their representation in post-secondary engineering programs nationwide.
- Female student participation in Project Lead The Way was comparable or exceeded the total proportion of females earning Bachelor's Degrees in Engineering in 2004, in the fields of Mechanical, Electrical and Computer Engineering, and in Engineering Technology, but less than the percentage in biomedical and environmental fields.

In October 2005, Project Lead The Way was cited in the report ***Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Educational Future*** by the National Academy of Sciences, The National Academy of Engineering, and the Institute of Medicine of the National Academies. Among the report's recommendations was that K-12 curriculum materials for STEM education modeled on world class standards should foster "*high-quality teaching with world class curricula, standards and assessments of student learning.*" It further went on to say that *"The model for this recommendation is the Project Lead The Way pre-engineering courseware* (page 4)."

Community Partners:

PLTW has numerous partners throughout the country that support the initiative nationally and locally, including:

- 30 colleges and universities (support teacher professional development in their states)
- 40 State Departments of Education (collaborate with universities and schools which oversee program implementation in their states)
- Corporations like Intel and Rolls Royce (underwrite national and state initiatives for teacher training)
- Agencies like NASA (collaborate on curriculum development)
- Associations like the National Fluid Power Association and the Society of Manufacturing Engineers (collaborate on curriculum development and extra-curricular initiatives)
- Organizations like the National Action Council for Minorities in Engineering and the National Association for Partnerships in Equity (collaborate on the minority and female participation issues)
- Institutions like the National Academy of Engineering's Center for the Advancement of Scholarship in Engineering Education (recognizes PLTW as the top pre-college engineering education program)