REPORT OF THE VIRGINIA DEPARTMENT OF EDUCATION

Report on Progress in Meeting Senate Joint Resolution No. 308, Establishing Shared Goals for an Engineering Program of Study with Shared Responsibility Among the Science, Mathematics, and Technology Disciplines

TO THE GOVERNOR AND THE GENERAL ASSEMBLY OF VIRGINIA

SENATE DOCUMENT NO. 13

COMMONWEALTH OF VIRGINIA
RICHMOND
2011

COMMONWEALTH of VIRGINIA

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December 8, 2011

The Honorable Robert F. McDonnell
Governor of Virginia
Patrick Henry Building, 3rd Floor
1111 East Broad Street
Richmond, Virginia 23219

Dear Governor McDonnell:

I am pleased to submit the Department of Education's report on Establishing Shared Goals for an Engineering Program of Study pursuant to Senate Joint Resolution Number 308 passed by the 2011 General Assembly of Virginia. The Resolution requests the Department of Education to submit an executive summary and report of its progress in meeting the directives of this resolution prior to the first day of the 2012 Regular Session of the General Assembly. A copy of this report will be submitted to the Division of Legislative Automated Systems and posted on the General Assembly's Web site.

If you have questions or require additional information relative to this transmittal, please do not hesitate to contact Michelle M. Vucci, director of policy, by e-mail at Michelle.Vucci@doe.virginia.gov or by telephone at (804) 371-0558.

Sincerely,

Patricia I. Wright

PIW/MMV/jf
Attachment

VIRGINIA DEPARTMENT OF EDUCATION

Report

REPORT ON PROGRESS IN MEETING SENATE JOINT RESOLUTION NO. 308, ESTABLISHING SHARED GOALS FOR AN ENGINEERING PROGRAM OF STUDY WITH SHARED RESPONSIBILITY AMONG THE SCIENCE, MATHEMATICS, AND TECHNOLOGY DISCIPLINES

PRESENTED TO

THE HONORABLE ROBERT F. MCDONNELL
GOVERNOR OF VIRGINIA
AND
THE VIRGINIA GENERAL ASSEMBLY

December 2011

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I. EXECUTIVE SUMMARY

Senate Joint Resolution No. 308 (SJR No. 308) requested the Virginia Department of Education (VDOE) to establish shared goals for an engineering program of study and assign a shared responsibility for the program among existing science, mathematics and technology education disciplines. The incorporation of engineering design is viewed as one effective methodology to apply mathematics, science, and technology content in practical ways.

The Career and Technical Education Office of the VDOE has traditionally been responsible for a range of rigorous engineering and engineering-related courses at the middle and secondary levels and has given significant support to infusing engineering design in elementary school programs. The current Standards of Learning for both mathematics and science have many connections with and supports for engineering, so greater incorporation of engineering design within these disciplines is a natural fit. Further, the 10 Governor's STEM (science, technology, engineering, and mathematics) Academies serve as excellent models for reinforcing engineering in the secondary curriculum, demonstrating practical applications and real-world connections.

In order to meet the intent of SJR No. 308, the VDOE convened a committee of engineering, higher education, and K-12 stakeholders to discuss how the agency might proceed in defining shared goals for an engineering program. Based on the input and recommendations from the committee, VDOE established four overarching goals for an engineering program of study:

GOAL I: Professional Development
Elementary, middle, and high school mathematics, science, and technology education teachers will enhance their understanding of and pedagogical skills for teaching engineering design by participating in high-quality professional development.

GOAL II: Policy
Virginia Board of Education regulations, documents, and communications will support the integration of engineering design in mathematics, science, and technology education.

GOAL III: Instructional Resources and Assessments
Curriculum materials and education resources for mathematics, science, and technology education will support the incorporation of engineering design in the K-12 program.

GOAL IV: Business Partnerships and the Work Force
Public/private partnerships will support sustainable programs that advance engineering design in the K-12 program and enhance a STEM-focused work force.

II. AUTHORITY FOR THE REPORT

The 2011 General Assembly passed SJR No. 308, which requested the VDOE to

- establish shared goals for an engineering program of study; and
- assign a shared responsibility for this program among the existing science, mathematics, and technology disciplines.

The Resolution further states that K-12 engineering

- not be subsumed by just one curriculum domain; but
- only be taught in conjunction with science, mathematics, and technology education;
- be taught by teachers with appropriate training in
    - the engineering design process;
    - the scientific method;
    - science; and
    - the manufacture to specifications and constraints.

To review SJR No. 308 in its entirety, refer to Appendix A.

III. BACKGROUND

Engineering as a Teaching Strategy

Integrative pedagogy and practice, formally drawing appropriate connections among the STEM disciplines, have remained largely the domain of the school division curriculum, the school, and the individual teacher. Pedagogy in mathematics, science, and technology education is not prescribed by the Virginia Board of Education, though all discipline areas have favored techniques based in research and tradition. However, the Teach Engineering Web site (that is supported by the National Science Foundation and the American Society for Engineering Education), succinctly states:

> Engineering design, by its very nature, is a *pedagogical strategy* that promotes learning across disciplines.

The 2011 Virginia General Assembly's SJR No. 308 reflects that perspective, promoting the multidisciplinary responsibility and cross-curricular application of engineering. In order for teachers to be able to incorporate engineering design and related concepts into instruction in mathematics, science, and technology education, they must fully understand those ideas and have useful models for making meaningful and effective connections with engineering. Similarly, science, mathematics, and technology education teachers must comprehend the question-answering and problem-solving practices that each discipline employs, where those practices are similar, and where they differ. Using engineering design and related concepts is another important teaching strategy that K-12 mathematics, science and technology education teachers can employ to improve student achievement across the STEM discipline areas. This view is well articulated in the 2010 *Science Standards of Learning* where it states:

> The application of science to relevant topics provides a context for students to build their knowledge and make connections across content and subject areas. This includes applications of science among technology, engineering, and mathematics, as well as within other science disciplines. Various strategies can be used to facilitate these applications and to promote a better understanding of the interrelated nature of these four areas. (p.vii)

Engineering in Technology Education

Leadership for K-12 engineering education in Virginia's public schools has traditionally been a key role of the technology education program of the Career and Technical Education (CTE) Office at the VDOE. The technology education unit has coordinated major efforts for engineering across kindergarten through grade 12, including developing supplementary resource materials, conducting professional development, collaborating with professional engineering education associations, and developing nationally-recognized learning competencies for middle and secondary engineering and engineering-related course offerings.

Through the technology education program, many elementary-school students begin to use the engineering design process in the classroom while mastering important Standards of Learning concepts, especially within science and mathematics. The technology education program has promoted *Children's Engineering*, a technology-based supplement to the Standards of Learning that promotes critical thinking, design and problem abilities. Students develop a technological awareness and explore how people create, use and control technology.

At the middle-school level, students apply higher-order thinking skills to solve engineering and technology problems. Through this program they explore careers and occupations in various fields of engineering and technology.

At the high-school level, the program content focuses on the study of a variety of technologies and challenges the student's ability to apply scientific principles, engineering concepts, and technological processes. Students enroll in specific courses to prepare for technical or professional programs of higher education, such as architecture, engineering, manufacturing, or other engineering and technology related careers. A sample of the 14 engineering courses conducted within the secondary technology education program includes

- Introduction to Engineering;
- Advanced Engineering;
- Introduction to Engineering Design;
- Advanced Manufacturing Systems;
- Digital Electronics; and
- Computer Control and Automation.

Engineering in the Standards of Learning

The 2010 *Science Standards of Learning* incorporate multiple entry points for engineering design and related concepts. Many core academic practices specifically defined in the standards and occurring at all grade levels are similar to those used in the engineering design process. For illustration, two pertinent practices identified in the science standards are the ability to

> apply the facts and principles (of science) to new problems or situations, recognizing what information is required for a particular situation, using the information to explain new phenomena, and determining when there are exceptions; and
>
> arrange and combine important facts, principles, and other information to produce a new idea, plan, procedure, or product. (p. vii)

Modeling, a key practice in engineering design, is well developed in both the mathematics and science standards across grade levels. An example from the mathematics and science standards respectively includes the following:

> using mathematical representations to model and interpret practical situations. (p. iv)
>
> designing, constructing, and interpreting models. (p. vii)

The phrase, "product design processes," is specifically included in the Physics Standards, PH.1, broadening the existing emphasis on rigorous science skills and scientific methodology to include a formal focus on the engineering problem-solving process.

Governor's STEM Academies and Engineering Education

Engineering and technology coursework is a key focus of the Commonwealth's 10 Governor's STEM Academies. The Academies are programs designed to expand options for the general student population to acquire STEM literacy and other critical skills, knowledge, credentials, and college-level credits that will prepare them for high-demand, high-wage, and high-skill careers in Virginia. Each Academy is a partnership among school divisions, postsecondary institutions, and business and industry.

STEM literacy at the Academies is an interdisciplinary area of study that bridges the four areas of science, technology, engineering, and mathematics. STEM classrooms shift students toward investigating, questioning, and applying the interrelated facets of the world. The Governor's STEM Academies are a practical complement to the academic year Governor's Schools and serve as centers where standards are raised and efforts are refocused to align with important science, technology, engineering and mathematics goals. Courses are held at high schools, technical centers, and community college campuses and are delivered in classrooms and laboratories, online, or through other innovative methods. Academy programs include internships, job shadowing, mentorships, projects, service learning, or a combination of these.

Additional background information on K-12 engineering education is included in Appendix B.

IV. ACTIONS TAKEN

Engineering Education Advisory Committee
To assist in responding to SJR No. 308, the VDOE convened a 16-member committee of key stakeholders to gather perspectives on meeting the intent of the Resolution. The engineering education advisory committee consisted of engineers; higher education science, technology, and engineering professionals; K-12 mathematics, science, and technology teachers and curriculum leaders; and business and community representatives. The committee provided a broad range of input concerning K-12 engineering education, and the key points of the day-long discussions were transcribed.

After a thorough analysis of notes taken during the stakeholder meeting, the VDOE organized the various recommendations under four major outcome headings, which became the four shared goals for developing an engineering program of study. The four goals are listed below, and the full description of the goals and specific actions that could be carried out to meet the goals is included in Appendix C.

GOAL I: Professional Development
Elementary, middle, and high school mathematics, science, and technology education teachers will enhance their understanding of and pedagogical skills for teaching engineering design by participating in high-quality professional development.

GOAL II: Policy
Virginia Board of Education regulations, documents, and communications will support the integration of engineering design in mathematics, science, and technology education.

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GOAL IV: Business Partnerships and the Work Force
Public/private partnerships will support sustainable programs that advance engineering design in the K-12 program and enhance a STEM-focused work force.

V. FUTURE ACTION

The VDOE is currently considering ways to implement the goals for a program of engineering education. Developing and carrying out supporting actions is viewed as a multiyear effort, potentially involving the review of the *Mathematics Standards of Learning* in 2016, the *Science Standards of Learning* in 2017, and various Board of Education documents on their regular revision cycles.

VI. APPENDICES

Appendix A

SENATE JOINT RESOLUTION NO. 308

SENATE JOINT RESOLUTION NO. 308

Requesting the Department of Education to establish shared goals for an engineering program of study, and assign a shared responsibility for this program between the existing science, mathematics, and technology disciplines. Report.

Agreed to by the Senate, February 2, 2011
Agreed to by the House of Delegates, February 22, 2011

WHEREAS, STEM is the acronym used in K-12 education for Science, Technology, Engineering, and Mathematics; and

WHEREAS, each component of STEM differs from the others in subtle but important ways; and

WHEREAS, science is concerned with the discovery of the laws by which nature works—the discovery of the natural world; and

WHEREAS, mathematics is concerned with the study of patterns and relationships among quantities, numbers, and shapes; and

WHEREAS, technology education is concerned with the modification of the natural environment in order to satisfy human needs and wants; and

WHEREAS, engineering is concerned with the creation of the human-designed world—the purposeful shaping of science and technology to meet societal needs; and

WHEREAS, innovation, critical thinking, and problem solving are highly desired twenty-first-century capabilities in the Commonwealth and the nation; and

WHEREAS, innovation is born directly of engineering rather than science and mathematics; and

WHEREAS, the engineering design process differs from the scientific method; and

WHEREAS, engineering design leads to the manufacture or fabrication of a product that meets design requirements and constraints; and

WHEREAS, engineering teachers require a significant background in the engineering design process and the manufacture to specifications process as well as science, mathematics, and technology education; and

WHEREAS, mastery in the engineering design process or manufacture to specifications process is not required of science and mathematics teachers; and

WHEREAS, mastery in science and mathematics is not required of technology education teachers; and

WHEREAS, a robust K-12 STEM education will lead students to successful transition to higher education in engineering; now, therefore, be it

RESOLVED by the Senate, the House of Delegates concurring, That the Department of Education be requested to establish shared goals for an engineering program of study, and assign a shared responsibility for this program between the existing science, mathematics, and technology disciplines; and, be it

RESOLVED FURTHER, That K-12 engineering not be subsumed by just one curriculum domain, but only taught in conjunction with science, mathematics, and technology education by

teachers with appropriate training in the engineering design process, the scientific method, science, and manufacture to specifications and constraints.

The Department of Education shall submit to the Division of Legislative Automated Systems an executive summary and report of its progress in meeting the directives of this resolution no later than the first day of the 2012 Regular Session of the General Assembly. The executive summary and report shall be submitted as provided in the procedures of the Division of Legislative Automated Systems for the processing of legislative documents and reports and shall be posted on the General Assembly's website.

Appendix B

K-12 Engineering Education Background

K-12 Engineering Education Background

Senate Joint Resolution Number 308
Through the 2011 Senate Joint Resolution Number 308 (SJR No. 308), the Virginia General Assembly has requested that the Department of Education undertake a process to

- establish shared goals for an engineering program of study;
- assign a shared responsibility for the program among the existing science, mathematics, and technology disciplines; and
- provide opportunities for the instruction of students by teachers with appropriate training in the engineering design process, the scientific method, science, and manufacturing to specifications and constraints.

Resource Documents
As a first step in preparing to meet the outcomes of SJR No. 308, Department staff examined recent publications that focus on various aspects of engineering education in the K-12 environment. These documents include:

- *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas,* National Research Council (NRC), 2011
- *Technology and Engineering Literacy Assessment and Item Specifications for the 2014 National Assessment,* National Assessment Governing Board (NAGB), 2010
- *Standards for K–12 Engineering Education?* National Academy of Engineering and National Research Council (NAE and NRC), 2010
- *Engineering in K–12 Education: Understanding the Status and Improving the Prospects,* NAE and NRC, 2009
- *Standards for Technological Literacy: Content for the Study of Technology,* International Technology Education Association (ITEA), 2007

In this process, Department staff focused on key information and recommendations in the documents that are directly pertinent to the outcomes of SJR No. 308. Important information from these four documents and other sources is organized in the following section and has been quoted in large sections with minor streamlining and formatting changes for brevity and clarity.

Status of Engineering Content in the Commonwealth's *Standards of Learning* and Career and Technical Education Competencies
The following 14 secondary engineering courses are offered in Virginia's public schools with enrollments in the first five courses totaling over 4,000 students. Eight courses are based on Project Lead the Way (PLTW), a nationally-recognized, rigorous and innovative high school engineering curricular program.

- Introduction to Engineering
- Advanced Engineering
- Introduction to Engineering Design (PLTW)
- Principles of Engineering (PLTW)

- Digital Electronics (PLTW)
- Computer Integrated Manufacturing (PLTW)
- Engineering Design and Development (PLTW)
- Aerospace Engineering (PLTW)
- Biotechnical Engineering (PLTW)
- Civil Engineering and Architecture (PLTW)
- Engineering Exploration
- Engineering Analysis and Applications
- Engineering Concepts and Processes
- Engineering Practicum

The *Science Standards of Learning* incorporate the "product design processes" into the Physics investigation standard, PH.1, broadening the existing emphasis on scientific methodology to include the engineering problem-solving focus. The stem of the PH.1 standard states, "The student will plan and conduct investigations using experimental design and product design processes."

The *Mathematics Standards of Learning* have a direct emphasis on problem solving, practical applications, and modeling; however, engineering references and applications are not mentioned specifically.

Research on Engineering Education for K-12 Students
The National Academies of Science 2010 report *Standards for Engineering Education?* concludes that more research is needed before standards are developed.

> The [Committee on Standards for K–12 Engineering Education] found very little research by cognitive scientists that could inform the development of standards for engineering education in K-12. This was also the finding of the Committee on K-12 Engineering Education, which authored *Engineering in K-12 Education: Understanding the Status and Improving the Prospects*, a 2009 report by the National Academies. (NAE and NRC, 2010, p.2)

Among the committee recommendations in the 2010 report were certain topics for future engineering education research, including

- how children come to understand (or misunderstand) core concepts and apply (or misapply) skills in engineering;
- effective ways of introducing and sequencing engineering concepts and skills for learners at different levels; and
- the best settings and strategies for enabling young people to understand engineering in schools, informal education institutions, and afterschool programs. (NAE and NRC, 2010, p.3)

The Role of K–12 Engineering Standards for K-12 students

The National Academies of Science Committee on Standards for K-12 Engineering Education conducted a two-year study which resulted in the report *Standards for Engineering Education?*

> The committee's charge was to assess the potential value and feasibility of developing and implementing content standards for engineering education at the K-12 level in the United States. . . In fulfilling its charge, the committee reviewed existing efforts to define what K-12 students should know and be able to do related to engineering; evaluated evidence for the value and impact of content standards in other areas of K-12 education; identified elements of existing standards documents for K-12 science, mathematics, and technology that could link to engineering; and considered how the various purposes for K-12 engineering education might affect the content and implementation of standards. (NAE and NRC, 2010, Preface vii)

> The committee concluded that, although it is theoretically possible to develop standards for K-12 engineering education, it would be extremely difficult to ensure their usefulness and effective implementation. This conclusion is supported by the following findings: (1) there is relatively limited experience with K-12 engineering education in U.S. elementary and secondary schools, (2) there is not at present a critical mass of teachers qualified to deliver engineering instruction, (3) evidence regarding the impact of standards-based educational reforms on student learning in other subjects, such as mathematics and science, is inconclusive, and (4) there are significant barriers to introducing stand-alone standards for an entirely new content area in a curriculum already burdened with learning goals in more established domains of study. (NAE and NRC, 2010, p.1)

Effective Ways to Integrate Engineering Skills and Concepts in K-12 Education

The Committee on Standards for K-12 Engineering Education, in its report *Standards for Engineering Education?*, "argues against the development of standards for K-12 engineering education at this time."

> Instead, we urge two approaches for leveraging current national and state standards to improve the quality of K-12 engineering education in the United States.
>
> The first approach, infusion**,** is a proactive strategy to embed relevant learning goals from one discipline (e.g., engineering) into standards for another (e.g., mathematics). This could be done most easily when state or national standards are being revised. The second approach, mapping, would involve integrating (or mapping) "big ideas" in engineering onto current standards in other disciplines. Mapping is a strategy for retrospectively drawing attention to connections that may or may not have been recognized by the developers of current standards. (NAE and NRC, 2010, p.1)

"Big Ideas" for K-12 Engineering Education

Two recently published framework documents present core ideas for K-12 engineering and technology.

Technology and Engineering Literacy Framework for the 2014 National Assessment of Educational Progress. The National Assessment Governing Board (NAGB) "stated that the goals and objectives of the framework and specifications should be based on the future needs of the nation and of individuals and on the levels of technology and engineering literacy likely to be expected of students in the first half of the 21st century (NAGB, 2010, p. 2)."

The framework is an inclusive document that extends well beyond core engineering ideas. It provides greater detail for student understanding for both technology and engineering at grades four, eight, and twelve. The overarching framework is outlined below.

Technology and Society
A. Interaction of Technology and Humans
B. Effects of Technology on the Natural World
C. Effects of Technology on the World of Information and Knowledge
D. Ethics, Equity, and Responsibility

Design and Systems
A. Nature of Technology
B. Engineering Design
C. Systems Thinking
D. Maintenance and Troubleshooting

Information and Communication Technology
A. Construction and Exchange of Ideas and Solutions
B. Information Research Investigation of Problems
C. Acknowledgement of Ideas and Information
D. Selection and Use of Digital Tools

A Framework for K-12 Science Education Standards: Practices, Crosscutting Concepts, and Core Ideas. This framework "represents the first step in a process to create new [national] standards in K-12 science education. . . . Of particular note is the prominent place given to the ideas and practices of engineering (NRC, 2011 p. viii)."

The committee recommends that science education in grades K-12 be built around three major dimensions. These dimensions are

- scientific and engineering practices;
- crosscutting concepts that unify the study of science and engineering through their common application across fields; and

- core ideas in four disciplinary areas: physical sciences; life sciences; Earth and space sciences; and engineering, technology, and the applications of science. (NRC, 2011, p. ES-1)

The full framework document provides greater detail for student understandings at grades two, five, eight, and twelve for each of the identified areas. The two core "Engineering, Technology, and Applications of Science" ideas in the framework are provided below.

ETS.1: Engineering Design

How do engineers solve problems?

ETS1.A: Defining and Delimiting an Engineering Problem

What is a design for?

What are the criteria and constraints of a successful solution?

ETS1.B: Developing Possible Solutions

What is the process for developing potential design solutions?

ETS1.C: Optimizing the Design Solution

How can the various proposed design solutions be compared and improved?

ETS.2: Links Among Engineering, Technology, Science, and Society

How are engineering, technology, science, and society interconnected?

ETS2.A: Interdependence of Science, Engineering, and Technology *What are the relationships among science, engineering, and technology?*

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, 2011, pp. 8-2–8-8)

The release of the *Next Generation Science Standards* is expected roughly one year after the release of the NRC's *Conceptual Framework for Science Education* (July 2011); public drafts will be available at roughly six months and nine months after the framework is published.

References

International Technology and Engineering Educators Association. (2007). *Standards for Technological Literacy: Content for the Study of Technology*. Retrieved July 28, 2011, from the International Technology and Engineering Educators Association Web site: http://www.iteaconnect.org/TAA/PDFs/xstnd.pdf

National Academy of Engineering and National Research Council. (2009). *Engineering in K-12 Education: Understanding the Status and Improving the Prospects*. Retrieved July 28, 2011, from the National Academies Press Web site: http://www.nap.edu/catalog.php?record_id=12635

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National Research Council. (2011). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas.* Retrieved July 28, 2011, from the National Academies Press Web site: http://www.nap.edu/catalog.php?record_id=13165

Appendix C

Shared Goals for an Engineering Program of Study

Shared Goals for an Engineering Program of Study

GOAL I: Professional Development
Elementary, middle, and high school mathematics, science, and technology education teachers will enhance their understanding of and pedagogical skills for teaching engineering design by participating in high-quality professional development.

- Use federal opportunities that support mathematics and science education to fund a pilot program where an institution of higher education provides professional development to K-12 mathematics and science teachers on engineering concepts, including the engineering design process, that augment Virginia's *Mathematics* and *Science Standards of Learning* (SOL) and Career and Technical Education (CTE) *Technology Education Competencies*.
    - ✓ This will be accomplished by a request for proposals (RFP) process that provides a grant opportunity to an institution or consortium of institutions of higher education, up to $500,000, for a 20-month implementation (January 2012 – September 2013) of the pilot.
    - ✓ Seek additional resources or encourage other partners to fund professional development beyond the pilot program.
- Encourage K-12 professional science, mathematics, and technology education associations to incorporate engineering education objectives into their professional development offerings.
    - ✓ Department of Education staff members, serving on state mathematics, science, and technology education professional association boards, will actively advocate for greater 1) inclusion of engineering-related content and examples in association-sponsored activities and publications and 2) coordination among the associations to meet shared objectives and shared responsibility related to engineering.
- Promote professional development opportunities on the infusion of engineering design for school division principals, central office administrators, and school board members to build awareness and ensure the support of instructional leaders and policy makers.
    - ✓ Department staff and collaborators will conduct sessions at VAESP, VASSP, VASCD, VSBA, and professional discipline-area teacher and leader conferences.

GOAL II: Policy
Virginia Board of Education regulations, documents, and communications will support the integration of engineering design in mathematics, science, and technology education.

- Review Board of Education regulations and documents and determine ways to expand and institutionalize integrated instruction on K-12 engineering in mathematics, science, and technology education.
- Examine current teacher licensure and licensure renewal requirements related to the teaching of engineering concepts.
    - ✓ Review the competencies for elementary and middle school teachers to determine what, if any, revisions are required to prepare teachers to infuse engineering concepts.

    - ✓ Review secondary mathematics, science, and technology education endorsements to determine what, if any revisions are required to prepare teachers to infuse engineering concepts.
    - ✓ Assess the advantages and disadvantages of creating an add-on endorsement for engineering (similar to that available for Algebra I).
- Establish common definitions for 1) science, technology, engineering, and mathematics; and 2) the pedagogical approaches STEM, engineering design process, and laboratory science.
- Appraise additional STEM measures related to K-12 engineering education as part of the Virginia Index of Performance (VIP).
- Monitor the development of the Next-Generation Science Standards (NGSS) (a multi-state/national effort coordinated by Achieve, Inc.) and review the alignment of the Virginia Science Standards of Learning to the NGSS and its expanded emphasis on engineering.

GOAL III: Instructional Resources and Assessments

Curriculum materials and education resources for mathematics, science, and technology education will support the incorporation of engineering design in the K-12 program.

- Identify common program objectives for the integration of engineering design in K-12 mathematics, science, and technology education.
- Develop curriculum maps that demonstrate where content from the *Mathematics* and *Science Standards of Learning* is well suited for infusing engineering design content.
- Identify an example curriculum coordination/integration model for the infusion of engineering concepts among the STEM disciplines, and provide samples of lessons for mathematics, science, and technology education using the model.
- Update the Department of Education curriculum supplement, *Children's Engineering: A Teacher Resource Guide for Design and Technology in Grades K-5.*
    - ✓ Use the most current state standards in mathematics (2009) and science (2010) and recommendations of the latest national K-12 engineering-education documents and reports.
- Develop an inventory/catalog of school divisions' successful implementation of STEM programs and share information about successful program innovations, models, and designs that are being used to incorporate engineering and integrated STEM into the K-12 curricula.
- Develop a site on the VDOE Web page dedicated to STEM and engineering content to highlight key Virginia engineering education contact persons and high-quality education resources, research, and programs in use in Virginia school divisions.
- Identify examples of classroom assessments that use engineering-related contexts for selected mathematics and science standards.

GOAL IV: Business Partnerships and the Workforce
Public/private partnerships will support sustainable programs that advance engineering design in K-12 schools and enhance a STEM-focused workforce.

- Encourage professional engineers and university engineering educators to become more actively involved in K-12 mathematics, science, and technology education professional development via education professional associations and school division collaborative efforts.
- Encourage business and industry partners to provide teacher and student internships and mentoring experiences that advance engineering education in K-12 schools.
- Contribute to a clearinghouse of K-12 education, business, industry, and higher education partners who will provide assistance to schools and divisions in the integration of engineering design in general and career and technical education programs.
- Cooperatively develop models of educational pathways that promote STEM/engineering careers and promote the value of the workforce readiness skills.