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Engineering Education in Nebraska Schools

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ENGINEERING EDUCATION IN NEBRASKA SCHOOLS

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Abstract: *Engineering education in Nebraska schools would benefit state and national goals to educate and equip students with the critical thinking skills necessary to support, and advance, ever-growing technology-based careers. The major industries of any state rely on a knowledgeable and skilled workforce. Engineering education, as engineering itself, is the interdisciplinary use of science, mathematics, and technology. Engineering education can fully and effectively utilize the collaboration of industry and education for the purpose of developing productive citizens through a defined and supported set of standards for all students in Nebraska schools.*

Background

Education in the United States can be both cyclical and trendy. Whether it is a method to teach mathematics or reading, experienced teachers can attest to “Here we go again!” or expose that the new method is a retread of something before. Nevertheless, new teaching and learning methods arise to effectively engage students. Interdisciplinary teaching and learning is one method that has proven to be a best practice. Interdisciplinary teaching and learning exemplifies the reality that no subject is independent of another. As a result, STEM (Science, Technology, Engineering, and Mathematics) education has steadily grown within United States and global education (Holt & Colburn).

Part of STEM education’s growth is spurred by the demand of industry and governments to ensure a workforce that can sustain and grow the countries in which they operate and serve. An example is President John F. Kennedy's "We Choose to Go to the Moon" speech in 1962 at Rice University in response to Russia's successful launch of Sputnik. That national charge contributed to an increase in STEM-related education and university research throughout the United States. The nation realized a 73% increase in STEM doctorates awarded the decade following the speech (National Science Foundation).

STEM education is regarded as an effective means to prepare students for 21st century societal and career demands (Holt & Colburn). In some cases, STEM education is treated as an independent subject (Koonce, Zhou, Anderson, Hening, and Conley). However, although it is increasingly used in classrooms and after school programs nationally and internationally, it is loosely defined and lacks national standardization. Given this lack of standards, and therefore teacher endorsement opportunities, STEM is often relegated to an instructional aid and/or supplement for teachers who may have no knowledge of, or training in, STEM education. But, as its acronym reveals, it is an amalgam of four subjects. Ideally, STEM demonstrates the near seamless synthesis of Science, Technology, Engineering, and Mathematics. And, when developed, implemented, and practiced as such, it can be a very effective teaching and learning model to actively engage students, teachers, and the community. Therefore, a baseline must be established to begin by asking, "What is STEM education?"

The acronym, and its underlying curricular foundation, is credited to Judith Ramaley of the National Science Foundation (Teaching Institute for Excellence in STEM). STEM education has experienced difficulty in attaining a footing pedagogically due to a lack of a unifying definition. As a result, there is inconsistent horizontal and vertical alignment of its content area. No two states, or even districts within a metropolitan area, may align horizontally grade for grade. In addition, many districts lack vertical alignment of content from grade to grade (National Science Board). However, the common thread in most STEM education programs or courses is the Engineering Design Process.

The Engineering Design Process is a cyclical, open-ended series of steps engineers use to solve a challenge. It is formally taught in universities and colleges engineering programs, and utilized in real-world engineering applications. Oftentimes, comparisons are made between it and the Scientific Method. However, the difference is that the Scientific Method tests a hypothesis through experimentation, and the Engineering Design Process designs a solution to a problem and tests its outcomes. Essentially, the Scientific Method results in knowledge (i.e., the hypothesis was valid, invalid, or inconclusive), and the Engineering Design Process results in a product, process, or system (e.g., a digital tablet, an electronic means of tracking attendance, or internet means of storing and sharing a patient's medical history) and the knowledge of all solutions – successful or not.

Implementing Engineering Education

Efforts are underway by several entities to address the need, or provide a means, to realize effective STEM education in classrooms and after school programs. Federally, the America Competes Reauthorization Act of 2010 produced the 5-Year Federal Science, Technology, Engineering, and Mathematics (STEM) Education Strategic Plan by the Committee on STEM Education (CoSTEM) (National Science and Technology Council Committee on STEM Education). Its five "Priority Investment Areas" are: Improve STEM instruction, Increase and Sustain Youth and Public Engagement in STEM, Enhance STEM Experience of Undergraduate Students, Better Serve Groups Historically Underrepresented in STEM Fields, and Design Graduate Education for Tomorrow's STEM Workforce. CoSTEM is comprised of several federal agencies, the National Aeronautics and Space Administration, the National Science Foundation, and the Smithsonian Institute. CoSTEM will provide human and material resources to train and support personnel and programs to meet goals set within its five Priority Investment Areas.

The National Science Teachers Association (NSTA) introduced the Next Generation Science Standards (NGSS) in 2013 through a group of 26 lead states, a writing team of science education experts, Achieve Inc., American Association for the Advancement of Science, and the National Research Council which partnered with many teachers and stakeholders in science and science education (National Science Teachers Association). To date, 12 states (RI, KY, KS, MD, VT, CA, DE, WA, NV, OR, IL and NJ) and Washington, D.C. have adopted the standards. NSTA promotes "STEM Starts Here". The NGSS' requirements for Engineering Design in integrated into its three content areas of Life Science, Earth and Space Science, and Physical Science. The NGSS is grouped into four grade categories: K-2, 3-5, Middle School, and High School. Its Engineering Design addresses three to four Performance Expectations related to Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts (NSTA).

Project Lead The Way (PLTW) is a 501(c)(3) non-profit organization that provides STEM education curriculum and teacher professional development in more than 6,500 K-12 schools. It provides Launch for K-5, Gateway for 6-8, and three high school programs: Computer Science, Biomedical Science, and Engineering. This is achieved through activity-, project-, and problem- based curricula with an engineering focus. PLTW is aligned with NGSS, Common Core, and most individual state standards. PLTW utilizes a Design Process to guide students through its curriculums. Launch and Gateway use a six-step Design Process while Computer Science, Biomedical Science, and Engineering use a 12-step Design Process. PLTW has an annual, per site participation fee (Launch - $750, Gateway - $750, Computer Science - $2,000, Biomedical Science - $2,000, and Engineering - $3,000). The participation fee includes curriculum, professional development, required software, and school and technical support (Project Lead The Way). PLTW also designates schools as certified or non-certified. Certification requires all the offering of all PLTW courses within a program and all PLTW teachers complete its professional development (PLTW).

International Baccalaureate® (IB) is an international non-profit educational foundation that provides an extensive curriculum and professional development that is consistent from one school to another within a district, state, or country (International Baccalaureate®). IB utilizes a Design Cycle to establish inquiry and process. The Middle Years Programme and Primary Years Programme use a four-step process with two to three sub-steps within each step to solve a problem. The main steps are Investigate, Plan, Create, and Evaluate. The Diploma Years Programme uses a four-step process with three to five sub-steps within each step to explore the nature of design in regard to creating a solution to a problem. The main steps are Analysis of Design Opportunity, Conceptual Design, Development of a Detailed Design, and Testing and Evaluation. IB provides its own set of subject standards. Schools are responsible to adhere to state, district, and IB standards. As a result, schools must attain authorization to become an authorized IB World School. Authorization requires a two-year probationary period of professional development and curriculum implementation. The candidacy fee for a school is $4,000. Upon satisfactory completion, the school is an authorized IB programme. IB offers four programmes: the Primary Years Programme (PYP, ages 3-12), the Middle Years Programme (MYP, ages 11-16), the Diploma Years Programme (DP, ages 16-19), and the IB Career-related Programme (CP, ages 16-19). The annual IB fees are as follows: PYP - $7,910, MYP - $9,055, DP - $10,820, and CP - $1,370. Individual schools purchase IB materials and training, as applicable, to maintain authorization. IB provides optional electronic assessment services with annual, per site fees (per subject fee - $725, student fee - $70, and eAssessment fee - $70).

Engineering Is Elementary® (EiE) - developed by the Museum of Science, Boston - is a STEM curriculum designed specifically for elementary school children (Engineering Is Elementary). It has two categories: Basic (grades 1-2) and Advanced (grades 3-5) and provides 20 units pertaining to a science topic and an associated engineering field (EiE). EiE utilizes a five-step Engineering Design Process: Ask, Imagine, Plan, Create, and Improve. It aligns with NGSS and individual state standards. Each unit is complimented with a companion storybook and international setting (stateside stories highlight African-Americans, Native Americans, and Mexican-Americans). EiE units require 8-10 class periods and are designed to be taught concurrently, or after, the mandatory subject topic. EiE produces teacher guides, lesson plans, storybooks, and material kits for purchase to support each unit. Each unit costs $408 initially, with material kit refills costing $100.

21st Century Community Learning Centers (21st CCLCs) - developed by the United States Department of Education - provide after school programs for academic enrichment opportunities for students who attend high poverty and low-performing schools (U.S. Department of Education). These after school programs provide a medium for local, site-specific administration of teaching and learning.

National Academy Foundation Schools provide site-based, themed academies within schools in the areas of Finance, Hospitality & Tourism, Information Technology, Health Sciences, and Engineering. The academies are framed to provide courses specific to its respective career theme.

Engineering Education in Nebraska Schools

The state of Nebraska Department of Education (NDE) does not directly address engineering education through explicit standards – just as many other states – due to the lack of an accepted definition and set of standards (U.S. Congress Joint Economic Committee). However, there are schools and after school programs within the state that provide the STEM education programs and resources. There are 18 PLTW schools:

School	Type	Program
Kearney High	Non-certified	Engineering
Lincoln High	Certified	Engineering
Lincoln East High	Certified	Engineering
Lincoln Southeast High	Certified	Engineering
Lincoln Northeast High	Certified	Engineering
McMillan Middle	Non-certified	Gateway
Millard North High	Non-certified	Engineering
Millard South High	Non-certified	Engineering
Millard West High	Non-certified	Engineering
North High	Certified	Engineering Biomedical Science
North Star High	Certified	Engineering
Northwest High (Grand Island)	Non-certified	Engineering Biomedical Science
Papillion-La Vista High	Non-certified	Engineering
Papillion-La Vista South High	Non-certified	Engineering
Pius X High	Non-certified	Engineering
Scottsbluff High	Non-certified	Engineering
Skinner Magnet Center	Non-certified	Launch

Southwest High	Certified	Engineering

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and one university affiliate at the University of Nebraska – Lincoln (Project Lead The Way), six authorized IB schools [Lincoln High School (DP), Millard North High School (DP and MYP), Central High School (DP and MYP), Millard North Middle School (MYP), Lewis & Clark Middle School (MYP, Omaha), and Aldrich Elementary School (PYP)] (Midwest IB Schools), and two National Academy Foundation schools [Omaha North High School (Academy of Finance) and Omaha South High School (Academy of Finance and Academy of Information Technology)]. In addition, there are 118 21st Century Learning Centers (Nebraska 21st Century Community Learning Centers). 21st CCLCs are partnered with the Nebraska BLAST! (Building Lasting Afterschool STEM Teams) program to provide STEM education. Nebraska BLAST! utilizes the NASA Summer of Innovation framework to engage students academically through unique design opportunities.

NDE provides academic standards that can be utilized for STEM education through the Technology component of Science content. NDE Science standards contain requirements for Grades 3 – 12 to solve a design problem through identification, design, implementation, evaluation, and communication (Nebraska Department of Education).

NDE does provide Career Technical Education standards for secondary education. Its Career Technical Education (CTE) is a collaborative between NDE and Partnerships for Innovation to provide secondary courses in specific career fields such as agriculture, business, communications, health sciences, human sciences, and skilled sciences (NDE). CTE standards are aligned with Nebraska academic and career readiness standards.

Similarly, SkillsUSA® is offered in Nebraska. SkillsUSA® is a not-for-profit 501(c)(3) association that helps students become world-class workers, leaders, and responsible citizens through 130 trade, technical, and skilled service occupational titles within 14 career clusters (SkillsUSA, see Table 3). There are 141 titles offered in class, or as extracurricular groups, throughout the state (SkillsUSA). Greg Stahr, SkillsUSA® Nebraska State Director, states there are 68 high school and 15 middle school "chapters" – schools that offer SkillsUSA® titles (G. Stahr, personal communication, May 11, 2015).

Conclusion

A contributing factor to the lack of dedicated STEM education in Nebraska schools, and around the nation, is the cost for formal programs, curriculum resources, professional development, and education administration support (Katehi, Pearson, and Feder). All states, and their respective school districts, contribute to the adoption of STEM education, along with community and industry stakeholders. The need to address the growth of advanced technology in society and careers begins in elementary and secondary schools. There are 1,248 elementary, 137 middle, and 310 secondary public, state-operated, and non-public schools throughout the state of Nebraska (Nebraska Department of Education). Therefore, with the existing STEM education programs within the state, there are more than 1,000 Nebraska elementary and secondary schools without any formal STEM education program or curriculum.

As of this year, 41 states – including Nebraska – provide components of engineering design through various content standards such as Science, Mathematics, and Technology (Carr, Bennett, and Strobel). Explicit engineering education standards can be found in California, Connecticut, Georgia, Indiana, Massachusetts, Minnesota, Mississippi, New York, Oregon, Tennessee, and Texas through adoption of curriculum engineering standards of Project Lead the Way (Carr, Bennett, and Strobel). Science and Mathematics serve as content bookends for STEM education. Mathematics has proven to be an effective means to implement explicit engineering education standards for Mississippi (Carr, Bennett, and Strobel). Nebraska addresses engineering design through Science content (Nebraska Department of Education). With its current exclusion of engineering design for K – 2, NDE is in position to provide a complete vertical alignment of Technology engineering design standards through grade-appropriate Science standards for Grades K – 2 that align with existing 3 – 12 Technology engineering design standards. In addition, NDE can provide direction for curriculum, resources, and administrative support to fully implement STEM education, and more so, engineering education, in the state of Nebraska through Science content standards, and explore the use of the Mathematics content standards. The use of Science and Mathematics content standards for implementing engineering education can prove to be cost effective and efficient with regard to resources. Engineering education standards adoption can be studied and based on existing, evidence-based models in Mathematics. Professional development can be expanded within both Science and Mathematics to equip educators to deliver an expanded, relevant curriculum based on adopted engineering education standards.

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