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Technology & Engineering in Delaware's K-12 Education: Today's Students, Tomorrow's Solutions

> One of the greatest challenges for those of us with engineering at the core of our businesses is securing a talented and diverse workforce for the future.
>
> -Greg Bentley, CEO, Bentley Systems[1]

Delaware's history is rich with innovations in science, technology, and engineering. Will the same be true about its future? Delaware's Economic Development Office reports that "Delaware has the second highest concentration of scientists and engineers in the United States. In addition, Delaware is ranked among the top 5 states in the nation when it comes to the number of patents issued per 100,000.[2]" Yet is this reality represented in today's K-12 curriculum? This policy brief examines the current national debate surrounding K-12 technology and engineering education and suggests some considerations for Delaware's policy makers.

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INTRODUCTION

In educational terms, technology and engineering form the center of the acronym STEM-Science, Technology, Engineering, and Mathematics. Even though most people loosely define "technology" as "computers" and report only vague understanding of engineering[3] we cannot imagine a future without either technology *or* engineers. To start a discussion about engineering and engineering education, the National Academy of Engineering developed several scenarios. What would the future look like if…?

- Advances in science, technology, and engineering benefit commerce, health, industry, and society in new and surprising ways; or if

- Opportunities for biotechnology to improve health and medicine were complicated by social and political forces which discourage progress in science and technology; or if

- Recovering from natural disasters, adapting to climate change, and predicting and softening nature's impact become real and pressing concerns for every city, state, and nation; or if

- An increasingly interdependent world becomes increasingly consumed in conflict and competition, not only in globalization and out-sourcing but in terrorism and violence as well.[4]

American students' interest in studying engineering, computer, and information science has been steadily declining for ten years.[5] Although the US currently graduates far fewer engineers and scientists than either China or India, 20% of undergraduates and over 50% of the doctoral students in American engineering schools are actually foreign.[6] This shortage when paired with the leveled competition of a global, digital economy has been compared to an economic and social "perfect storm."[7]

While the importance of STEM education to the nation's and the state's workforce is fairly clear, its wider benefits to education and citizenship are becoming more evident as well. For example, recent polls show that Americans want schools to teach problem-solving, collaborative work skills, and other skills to help students make connections between school and the "real world."[8] There is also a growing concern that citizens who are poorly informed about technology will be unable to judge or contribute to democratic decisions about its development and use.[9] [10] Even our future national security, relying heavily on both engineering and technology, will be impacted.[11] [12] [13]

Project-based technology and engineering instruction may play a part in solving some of these problems. In one recent example, middle school students from Louisiana designed and modeled an award-winning city of the future. "Using innovative technology and modern engineering practices" they responded to a real-world challenge– energy and fuel shortages–by using primarily renewable resources in planning for housing, transportation and industry.[14]

WHAT DOES RESEARCH IN TECHNOLOGY AND ENGINEERING EDUCATION TELL US?

- British middle and high school students in Design and Technology courses were motivated and excited about learning. They had higher grades, better attendance, showed greater persistence and more self-confidence.[15]
- Students in Israel who learned introductory engineering through a project-based approach reported they acquired multidisciplinary knowledge; engaged in active and meaningful learning; used analytic, synthetic, design and systems thinking; and experienced a collaborative learning process.[16]
- Eighth graders who state an interest in science and engineering careers are more likely to persevere and ultimately graduate in those fields than students of similar or *greater* academic abilities (mathematics) who have not expressed an interest in those careers.[17]
- Engineering's tools of thought include creativity, imagination, innovation, problem solving, evaluation, analysis, synthesis, intentionality, collaboration, exploration, and planning.[18] [19] [20]
- Even very young children are able to question and think like engineers. Creative imaginings and vivid curiosity fill their playtime. They are capable of making simple deductions from observations and designing experiments to learn more.[21]

STEM: AN INTEGRATED EDUCATION MODEL

"Teaching math and science, *as well as* technology and engineering, in our elementary and secondary schools is a vital 'stage-setting' function–it allows students to acquire highly valued skills in their later education, solve problems, become innovators and experimenters, and be effective citizens of a society that will require growing awareness of scientific issues."

- Everett Erlich, chair, National Governor's Association[22]

Governor Erlich joins a growing chorus of policy makers, educators, and professionals calling for the full integration of technology and engineering (or T&E) into the required K-12 curriculum. There are national examples in the International Technology Education Association's (ITEA) Standards for Technological Literacy, co-funded by NASA and the NSF[23] and in the Ford Partnership for Advanced Studies, an integrated, interdisciplinary STEM curriculum sponsored and supported by the Ford Motor Company.[24] However, both are voluntarily adopted programs.

In 2006, Massachusetts updated and adopted Pre-K to 12 standards for integrated, inquiry-based instruction, the *Massachusetts Science and Technology/Engineering Framework.*[25] Its philosophy and vision is guided by several principles, one of which is the principle of interconnection:

> "Each domain of science has its particular approach and area of focus. However… much of real scientific work draws on multiple disciplines. Oceanographers, for instance, use their knowledge of physics, chemistry, biology, earth science, and technology to chart the course of ocean currents. Connecting the domains of natural science with

mathematical study and with one another, and to practical applications through technology and engineering, should be one goal of science education." (p. 13)

There are other states working to unite these fields of study. In 2006, the state of Rhode Island allocated funds for all 67 of its high schools, secondary charter schools and vo-tech schools to field a competitive robotics team through a program called FIRST (For Inspiration and Recognition of Science and Technology.) This move brings together the state's desire to integrate their STEM education standards and provides opportunities for students to meet the state's new graduation requirement– the demonstration of applied learning skills.[26] [27]

ENGAGEMENT ENABLES ACHIEVEMENT

Hacker (in Keirl[28]) describes the passionate engagement within the work of engineering. "This field, the apparent epitome of cool rationality, is shot through with desire and excitement. Much of this excitement stirs the mind…. [Its] expression finds its most creative outlet today in the design of technology. Technical skills and activities… fire the imagination of many." T&E education generates an enthusiasm and commitment to learning which may offer a cure for an ailing educational system– an opportunity to motivate students, increase academic rigor, and make high academic expectations attainable and meaningful for all.

DELAWARE SITUATION

Delaware's recently revised K-12 science curriculum is inquiry based and has been recognized for the high levels of engagement it creates for students and teachers alike,[29] but our technology standards are elective and not core curriculum areas.[30] Delaware's "Tech Ed" system is built on an occupation skills model and is moving to career pathways. There is no planning at this time for a fully integrated STEM program for all students- regardless of their interest or career goals, whether they are bound for college or the world of work.

The future is in technology. It will be designed and built, in large part, by engineers. Children understand and embrace this vision. How can we engage and teach them to become actors in the reality in which they will live? To paraphrase Governor Erlich, how can we "set the stage" for their success with the technological challenges that lie ahead?

POLICY QUESTIONS FOR CONSIDERATION

1. What resources already exist within the state and within DOE to raise awareness and provide teacher training on the T&E aspects of STEM?
2. How might schools partner with DE technology and engineering organizations to bring engineering themes into K-12 classrooms?
3. How might Delaware's curriculum tap into the creativity and collaborative problem solving found in contextualized engineering applications to increase overall student engagement and understanding?

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