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TechXcite: Discover Engineering—A New STEM Curriculum

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Abstract

TechXcite is an engineering-focused, discovery-based after-school science, technology, engineering, and math (STEM) program. The free curriculum is downloadable from http://techxcite.pratt.duke.edu/ and is comprised of eight Modules, each with four to five 45-minute activities that exercise the science and math learned in school by using engineering principles to build products or learn processes that improve the quality of life. Ninety-eight percent of TechXcite instructors indicated that students learned and demonstrated improved competence in science and engineering. TechXcite Modules include building prosthetic arms, infrared remote controls, solar-powered cars, harvesting rain water, and imaging biological systems.

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Introduction

TechXcite: Discover Engineering! is an out-of-school science education curriculum developed by the Pratt School of Engineering at Duke University and funded by the National Science Foundation. TechXcite involved a partnership between Duke University, the National 4-H Council, and the North Carolina 4-H program. The curriculum is centered on four themes: Biotechnology, Green Engineering, Alternative Transportation, and Wireless Communication. The curriculum was pilot-tested in 4-H sites across seven states: North Carolina, California, Michigan, Mississippi, Missouri, Oklahoma, and West Virginia. Building upon the work of previous science and technology after school programs, the TechXcite curriculum aspires to achieve the following three primary audience impacts:

- Improvement in student participants' attitudes, motivations, and competencies in science, engineering, and technology;

- Increase in student participants' abilities in applying information learned in science/technology/engineering to real-life problems/situations; and

- Increase in student participants' content knowledge and understanding of Discover Engineering! modules/lessons that have been completed.

Research Base

Studies of informal science education programs have recommended emphasizing human versus technological aspects of science in curriculum design to "increase the appeal of topics across gender" (Crane, Nicholson, Milton, & Bitgood, 1994, p. 30) and "making STEM fields more attractive...to girls by...promoting science as a human inquiry, involving the hands and the heart as well as the brain, one's personal interests and tastes––rather than an anonymous application of a universal method" (Froschl, Sprung, Archer, & Fancsali, 2003). "New teaching and learning models are needed to provide students with the ability to engage in scientific inquiry" (Skelton, Seevers, Dormondy, & Hodnett, 2012).

For both genders, hands-on experiences such as using tools and equipment have been found to enhance interest in science (Hansen, Walker, & Flom, 1995) and are related to higher math and science achievement (Campbell, Jolly, Hoey, & Perlman, 2002). Girls, in particular, were six times more likely to consider engineering as a career following hands-on engineering activities (Campbell & Shackford, 1990).

The TechXcite: Discover Engineering materials have embraced these research findings to develop a research based project that attracts all students, boys, girls, rural, and urban, in afterschool programs to STEM fields and careers through engaging, substantive, and applicable hands-on lessons.

Curriculum Evaluation

Techxcite was evaluated with pre-post youth knowledge survey instruments, instructor survey instruments, and youth focus groups. Protocols were co-developed by Duke University staff and the external evaluation team, Compass Evaluation and Research, Inc.

Summative evaluation questions for TechXcite included the following:

1. To what extent is there increased student understanding/knowledge of, and literacy about, science/engineering/technology (male vs. female)?

2. Is there increased student understanding of real-world science/engineering/technology problems?

3. Is there improvement in students' attitude, motivation, self-confidence, and competence towards science/technology?

4. To what extent is there increased student interest in science/engineering/technology careers?

Summary of Evaluation Findings

Evaluation results generated by Compass Research and Evaluation (2014) indicated that 98% of instructors believe that students learned and demonstrated improved competence in science and engineering. Results also indicated that the modules were applicable to real-world situations (96%) and provided real-world examples and uses of technology (85%). With respect to gender differences, instructors very much or completely agreed that both male students (87%) and female students (72%) were engaged with TechXcite. Most instructors very much or completely agreed that after participating in TechXcite students showed improved attitudes toward science and engineering (65%), increased confidence in science and engineering (63%), and increased initiative to explore science and engineering topics (64%).

With respect to gender differences, the ratings indicated that instructors believed both male and female youth actively engaged in TechXcite. Instructors also indicated that after participating in TechXcite, students showed improved attitudes toward science and engineering, increased confidence in science and engineering, and increased initiative to explore science and engineering topics. Evaluation results indicated that students enjoyed the program, would like to do more activities like TechXcite, and learn even more about science, engineering and/or technology.

Curriculum Content

Curriculum modules have been categorized into four subject categories—Biotechnology, Green Engineering, Alternative Transportation, and Wireless Communication. Two Biotechnology modules—Bionic arm and Bio-imaging—focus on engaging participants in the medical application of engineering. Using balsa wood and pulley systems, youth build a prosthetic arm moved by pneumatic and hydraulic systems. The bio-imaging lessons create a device that registers sound imaging to impart how medical imaging works.

Green Engineering curricula, focused on how engineering provides support for renewable energy applications, consist of two modules—Cooking with the Sun and Green Building Rainwater Harvesting. Participants build solar ovens based on solar energy principles, while green buildings bring attention to a roof-top water collection system through design and construction activities.

Alternative Transportation modules emphasized sustainable resource engineering through building vehicles. Using K'NEX materials, a basic car structure is designed, built, and redesigned to test several energy methods of motion in the Quest for Speed module. Racing with the Sun spotlights solar energy as a means of renewable energy for transportation.

Wireless Communication is the final theme and brings attention to radio transmission technologies as youth build an electrical system that transmits sound using infrared light in Your TV Remote module.

Conclusion

The following quotes represent the many thoughts shared by county agents, 4-H volunteers and afterschool staff.

> TechXcite was a wonderful program which brought opportunities for our youth to get hands on discovery based learning experiences. We implemented the program during our after school program. The youth got excited every week when it was TechXcite time; therefore they were very engaged in the materials and activities provided. We will continue to use TechXcite as our youth really enjoyed the program.—Air Force Base Afterschool Educator

> The TechXcite programs implemented in our county were a very positive experience. The youth enjoyed the hands on activities. The curriculum encouraged the youth to think and question as scientists. We will be happy to continue using modules from the TechXcite program.—County 4-H Agent

The TechXcite modules are available at the TechXcite website, http://techxcite.pratt.duke.edu/. The website provides free curriculum downloads and material lists needed for each activity. Plus, it contains the bonus feature of online tutorials that demonstrate tips and tricks to make this STEM based curriculum successful.

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