TECH-EXPLORER: ENGAGING STUDENTS IN STEM EDUCATION AND TECHNICIAN CAREERS PROJECT OUTCOMES

In 2010, Sierra College won a $150,000 National Science Foundation (NSF) Advanced Technological Education grant (DUE 1003259) to infuse algebra into the *Tech-Explorer* learning experience where students transform industrial materials into a functioning catapult using a mill, lathe, drills, and other common industrial tools. The project emphasized attracting girls and women to STEM (Science, Technology, Engineering, and Mathematics) careers and made a special effort to bring *Tech-Explorer* to a variety of schools and socio-economic levels: urban, suburban, rural, alternative, court ordered, as well as Sierra College Mechatronics classes.

During the project, a total of 306 students over 11 events experienced the math-infused catapult-building project; and a total of 32 faculty members participated in three workshops. Through the *Tech-Explorer* catapult events, students experienced how a technician, engineer, or product designer uses math on the job. Faculty members participating in the workshops learned how to teach using project-based learning with a theme: mathematics is fun, useful, and has to be practiced.

Learning objectives were that students will:

1. Experience what it is like to be a technician in a manufacturing or repair environment;
2. Practice applying decimals, fractions, and reading a scale;
3. Experience the concept of a parabolic curve, and the equation, as it relates to a catapult ball height, velocity, and distance;
4. Know how a parabolic curve applies to everyday products;
5. Understand that an object launched into the air (with no other forces besides gravity and air resistance) will follow a parabolic path on its way back down to the ground;
6. Know a parabolic path is dependent on the angle at which the object is launched;
7. Know there are formulas that can be used to find things such as maximum distance, optimal angle, and maximum height; and
8. Generate a parabolic equation from data gathered through hands-on experiments.

As the project team integrated a parabolic equation lesson (associated with a launched ball's trajectory) into the *Tech-Explorer* catapult fabrication unit, it was clear that many students were not prepared to understand this equation due to a lack of understanding of the Seven Essentials of mathematics (measurement, fractions, ratios/proportions, probability, decimals, percent, and geometric reasoning). Consequently, the project team experienced, first hand, what the National Mathematics Advisory Panel stated in their 2008 report – the lack of understanding of fractions is pervasive and an obstacle to further mathematics progress. As a result, a pivotal decision was made to add a refresher

exercise on fractions, decimals, and reading scales before a catapult fabrication event. It was at this point that the project took on the challenge to measurably improve student understanding of the Seven Essentials through engaging project-based learning strategies.

Major Findings

1. The lack of understanding of fractions and other critical algebra foundations is an obstacle to comprehending a parabolic equation and must be addressed.
2. Students will engage in mathematics when they see there is a use for it.
3. A master teacher is a key component of delivering new education concepts.
4. Preparing teachers with hands-on math-related projects is a significant opportunity to change how math is taught.
5. Math concepts must be practiced over the course of a semester.
6. Checking work must be emphasized to reflect industry quality control practices.

Teachers involved with this project were enthusiastic about the engaging hands-on lessons; the opportunity for students to use a variety of tools and materials as they applied math; and the exposure to technical career pathways. The **broader impact** of the *Tech-Explorer* project is threefold: 1) project outcomes were designed to be transferable to diverse educational settings; 2) the curricula will enhance existing courses as it improves student learning outcomes; and 3) the curricula and teaching practices advance understanding of how project-based activities help students learn and retain mathematics. Furthermore, project curricula are available as a turnkey instructional package through the Internet for implementation at http://sierraschoolworks.com/section/tech-explorer/nsf-grant/

The catapult project has been implemented at College of the Canyons, College of the Sequoias, and San Bernardino Community College. It has been used in Tennessee by the Regional Center for Advanced Manufacturing's Advanced Manufacturing Camp for 8-9th graders. Additionally, Nebraska's Columbus Public Schools district incorporated *Tech-Explorer* into their project SHINE, a program that exposes both teachers and students to STEM.

The **intellectual merit** of the *Tech-Explorer* project is that the model, using hands-on projects connected to authentic work situations, can provide fundamental improvements in teaching mathematics as it improves student preparation for STEM technician education and careers. An important feature of the *Tech-Explorer* curricula is that its design and implementation was led by practicing faculty in mathematics and technical education, using the guiding principle that life is an integrated activity. As such, integrating practical application into math classes and math into the still-existing technical classes is imperative.