Best Practices Panel Winners
ASEE K-12 Engineering and Pre-College Outreach Division

The K-12 ENGINEERING AND PRE-COLLEGE OUTREACH DIVISION of ASEE is recognizing exemplary K-12 – university partnerships in engineering education at the 2009 ASEE Annual Conference and Exposition in Austin, TX. To do this, the Division is sponsoring a panel session on Best Practices in K-12 and university partnerships. Submissions chosen for participation in this session demonstrate a true partnership between a K-12 school (or schools) and an engineering school/college at a university.

Selected partnerships have proven success in the classroom and demonstrate engineering engagement and knowledge acquisition by K-12 students through age appropriate activities and lessons. Best Practices Partnership Panel winners' papers are authored collaboratively between engineering and technology education faculty and K-12 teachers. Details on the partnership's structure and goals and the successful strategies employed to overcome challenges and obstacles are included. Each partnership's description includes sample student product(s) and conveys how other partnerships may emulate the project.

One proposal winner was chosen by a panel of reviewers at each of the following levels: pre-school or elementary school; middle school; high school. The three winning abstracts have been used to create a conference paper for this session.

PRE-SCHOOL / ELEMENTARY SCHOOL WINNER

Partnership to Improve Student Achievement through Real World Learning in Engineering, Science, Mathematics and Technology

Dan Fagan, Wallace Primary School, Hoboken, NJ
Carol Shields, Stevens Institute of Technology, Hoboken, NJ

Program Overview & Partnership Structure

The Partnership to Improve Student Achievement (PISA) project is a New Jersey Department of Education-sponsored Math-Science Partnership (MSP) grant that provides elementary teachers in New Jersey with professional development in innovative, research-based, science and engineering curricula; classroom-based technical and pedagogical support; and ongoing coaching and mentoring. Two universities, a science center, and a teacher education institution are collaborating in delivering these services to 56 Grade 3-5 teachers from six urban districts in Northern New Jersey.

The Center for Innovation in Engineering (CIESE) at Stevens Institute of Technology is the lead partner in the program. The two-week summer institutes are held on the Stevens Campus and they are planned and conducted by two CIESE staff members who also conduct follow-up site visits during the year. Professors from Monclair State University and Stevens engineering faculty serve as visiting lecturers and advisors. Staff from Bank Street College of Education
reviews program material for pedagogical content. During the school year Liberty Science Center hosts three program-related professional days for the PISA participants.

MSP program goals focus on strengthening teacher content knowledge in science and mathematics in order to improve student achievement in these subjects. The involvement of science, technology, engineering, and mathematics (STEM) faculty at institutions of higher education is a requirement of all MSP grants. The PISA program presents a novel approach to accomplishing MSP goals by integrating the use of exemplary, research-based elementary engineering curricula, engineering explorations and problem-based activities to strengthen teachers’ science learning. An intensive summer institute, followed by in-class mentoring and coaching support, and online help, represent key program components.

**Partnership Goals**

The overarching aim of the three-year PISA program is to: (a) demonstrate and institutionalize within participating schools a methodology, supporting curriculum materials, and other instructional resources and strategies to increase student interest, engagement, and achievement in science, mathematics, engineering, and technology and further, to (b) promote a culture of inventiveness and creativity that calls upon students to demonstrate 21st century workforce skills and to apply science and mathematics toward the solution of relevant, real-world problems. Specifically, partnership goals were to (a) improve participating teachers’ content knowledge in life and environmental sciences and technology (information technology and engineering), and (b) improve teachers’ pedagogical knowledge in creating and adopting science inquiry and engineering lessons, and (c) improve the content knowledge of students in Grades 3-5 in life, earth and physical sciences and technology.

**Program Content**

Each year of the three-year MSP program focuses on a different science discipline. The first year focused on life science, environmental science, engineering, and use of computer technology; year two, which ended June 2008, focused on earth and space science; and the final year will focus on physical sciences. Scientific inquiry and the engineering design process provided the focus and coherence to the topics and concepts covered in this program. The engineering activities provided the hook for participants to learn science. The *Engineering is Elementary* (EiE)\(^1\) curricula were used as the vehicle to help teachers apply their learning to a real-world problem and to introduce teachers to the engineering design process. The EiE curricula, developed by the Boston Museum of Science, integrate engineering and technology concepts and skills with elementary science lessons. EiE materials engage students in hands-on, real world engineering experiences that can enliven science lessons and motivate students to learn concepts by illustrating relevant applications.

**Proven Success in the Classroom**

Teachers reported that PISA activities provided opportunities for their students to use critical thinking skills and to do scientific inquiry. Students were active learners and their motivation was positively affected; they were engaged and excited. One vice principal of a partner school
reported that many of her troubled students who engaged in PISA-designed activities were motivated and engaged to learn science because of the engineering challenges.

The use of inquiry-based science and of research-based, interdisciplinary, hands-on curricula and instructional strategies for science and engineering for participating teachers has had a significant impact on student learning of life science topics and processes, technology, and engineering. Students have demonstrated increased interest and engagement, and improved critical thinking, scientific inquiry, and teamwork skills as a result of their teachers’ participation in the PISA program.

Dan Fagan, a PISA participant and third grade teacher at Wallace School in Hoboken is a model teacher whose work exemplifies how a classroom teacher can successfully integrate engineering activities into the existing curriculum. Dan plans and works closely with the science resource teacher in his building. In year one of the PISA program, he implemented the following EiE modules: Water, Water, Everywhere: Environmental Engineering; Best of Bugs: Agricultural Engineering; and Just Passing Through: Bioengineering. In year two, he implemented: A Sticky Situation: Materials Engineering and Catching the Wind: Mechanical Engineering. Dan uses the EiE materials in conjunction with related science topics and has found that the EiE lessons further his objectives for science in the classroom and reinforce concepts taught in class. For example, upon completing a science unit on plant parts and propagation last spring, he implemented “Best of Bugs” in which the students design and construct a hand pollinator. His students feel comfortable using the engineering design process and it is obvious to the observer that his students were engaged and excited; they have learned that there are different ways to solve problems. Dan reports that his students’ understanding of and positive attitude toward science has improved as a result of interaction with the EiE materials. Dan’s class recently completed the EiE module A Sticky Situation: Designing Walls in which the students tested various earth materials to determine which produced the strongest mortar. They wrote and drew a plan for making a mortar mixture and building a rock wall with it. Finally they tested the strength of their walls. Dan used this EiE module as an introduction to his rocks and minerals unit. See the following planning sheets and photographs.

**Strategies Employed to Overcome Challenges and Obstacles**

Challenges were encountered during this program yet they did not hinder its success. Creative strategies were employed to overcome obstacles. For example, to demonstrate the need, the value, and the impact of the PISA program, information sessions specifically planned for the administrators of participating districts were given. In addition, to best meet the needs of four school districts whose curriculum guides differ greatly in scope and sequence, the New Jersey Core Curriculum Content Standards were used as the basis of our professional development program.

The critical elements of success are committed partner schools and strong relationships with the teachers. The use of commitment forms signed by the teachers and administrators with expectations clearly explained proved to be successful tool. To ensure that teachers implement the content and skills learned during the professional development and remained motivated and excited about their participation in the program, monthly classroom visits and mentoring via the
program listserve as well as email and phone calls have proven invaluable. Both the teachers and principals reported that classroom visits by CIESE staff greatly contributed to the success of the program so far. CIESE staff also maintains a PISA website that features recommended resources and highlights of the school year. Recommended strategies for classroom visits are a combination of co-teaching, modeling, and observation/feedback. Moreover, it can not be emphasized enough, that encouraging the teachers and helping them get past any barriers was the heart of the mentoring and ultimately the success of the program.

References
Designing a Wall
Engineering Design Process: Ask!

Directions: Think about your observations of the soil, sand, and clay mortars and answer the following questions.

1. Which earth material(s) do you predict will make a strong mortar? Why?
   These materials I will use is silt and clay because clay is strong and sand is a little strong and together it is stronger.

2. Which earth material(s) do you predict will NOT make a strong mortar? Why not?
   The material I will not use is soil because if you put the soil in between to rocks and it will fall out.

EIE: Designing Walls
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Designing a Wall

Engineering Design Process:
Ask!

Directions: Think about your observations of the soil, sand, and clay mortars and answer the following questions.

1. Which earth material(s) do you predict will make a strong mortar? Why?
   
   I would want to you these because clay will crumble but some sand and soil makes it look like it is going to not fall. The materials that I would use are clay, sand, and soil so it will because it would stay together.

2. Which earth material(s) do you predict will NOT make a strong mortar? Why not?
   
   There are none of them because if you put it all together it will look like it will not stay up but if you put it all back like it is good. They will all work because they all can stick together but when you put clay it won't stick so I chose it all.

EiE: Designing Walls
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Lesson 4: Designing a Wall
4-3
What Materials Would You Choose?

Directions: From what material or materials do you think Yi Min and Chen should build their wall?

• Circle the materials that you think they should use.
• Draw a picture of what you think the wall would look like in the box.

wood  cloth  rocks

glass  metal
Designing a Wall
Engineering Design Process: Plan!

1. Which earth material(s) will you use in your mortar mixture? Write the earth materials in the 3 scoops below.

   Scoop #1 will be: **Clay**
   Scoop #2 will be: **Soil**
   Scoop 3 will be: **Sand**

   Mortar Mixture

2. Draw a picture of how you will build your wall using mortar and rocks in the box below. How will you stack the rocks?

3. Why do you think this wall design will work well?
Wall Walk

Directions: Take a walk and look for different kinds of walls. In the boxes below, draw pictures of four different walls that you see. If you recognize any of the materials used in the walls, label them.

Wall 1
- Little rough bricks, mortar
- Big bricks

Wall 2
- Rough bricks mixed with little pebbles and mortar
- Skinny wall

Wall 3
- Shiny, huge rocks
- Huge bricks

Wall 4
- A different pattern and mortar
- Upside down bricks

EiE: Designing Walls
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MIDDLE SCHOOL WINNER

University Education Program Partners with Public Middle School to Integrate Engineering into Classroom and After School Instruction

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Introduction

According to recent statistics published by the National Academies, “Just more than one-third of fourth graders reached the proficient level in mathematics in 2005, and the rates were lower for mathematics at grades 8 and 12, and at all three grades for science. International comparisons of student mathematics and science performance indicate U.S. students perform below average in mathematics and science for industrialized countries [1]. At the same time, the U.S. Bureau of Labor Statistics predicts that the number of jobs in science, technology, engineering and mathematics (STEM) occupations will grow by 47 percent by the year 2010, three times the rate of all other occupations [2]. According to a recent report from the National Science Foundation [3], however, the United States is experiencing a chronic decline in homegrown STEM talent and is increasingly dependant upon foreign scholars to fill workforce and leadership voids. Clearly, if the United States is to maintain its competitive edge in the global economy, we must increase the pipeline of interested and qualified students prepared to enter STEM careers. The introduction of engineering into the K-12 classroom, which may be facilitated by partnerships between universities and K-12 schools, is a promising means to accomplish this goal.

This abstract describes one such partnership between an eighth-grade science teacher at an urban middle school and faculty from the Technology and Engineering Education Department of a neighboring university. Technology and Engineering Education, K-12, a program housed in the School of Engineering and Technology of the university partner, is a comprehensive pre-engineering undergraduate program that prepares students for teacher certification, grades K-12. Throughout the program, emphasis is placed on designing, developing and using technological systems; open-ended problem-based design activities; and applying technological knowledge and processes to real-world experiences utilizing up-to-date resources. Technology and Engineering Education majors complete a core of technology courses, involving classroom and laboratory experiences, as well as general education requirements. Preparation as a technology educator also entails a series of practicum courses, which require extensive field experience with K-12 students. These are separate from the student teaching requirement, and undergraduate students from all levels participate.

Central Connecticut State University (CCSU) Practicum Courses

In one of these courses, “TE 155: Integrating Engineering Concepts for K-8 Students,” undergraduates develop and teach original engineering lesson ideas that are specifically tailored
to this age group and aligned with state standards for their grade levels. The course goals are listed below:

- Define technology and what it means to be technically literate.
- Demonstrate familiarity with national and state standards for technological literacy.
- Identify technological concepts appropriate for children at different developmental levels.
- Identify engineering activities and opportunities appropriate for the teaching, learning, and assessment of K-8 students.
- Collect and assess information pertinent to K-8 technology and engineering education.
- Create a model of spiraling technological concepts and assessment throughout and beyond the K-8 curriculum.
- Integrate technology standards into K-8 curricula.
- Integrate standards from other subject areas, such as language arts, social studies, science, and mathematics, into technology activities.
- Create robust and meaningful assessments of technological concept acquisition appropriate for students in grades K-8.
- Structure engineering challenges, materials, and activities for K-8 students.

Specific lesson topics have included environmental engineering and bridge building among others, and students are required to utilize the activity templates available at teachengineering.org when developing their original lesson ideas. Teachengineering.org is a collaborative project between faculty, students and teachers associated with five universities and the American Society for Engineering Education, with NSF National Science Digital Library (NSDL) funding. At the end of the semester, students are encouraged to submit their new curricula to this web site for review and possible publication.

In a second practicum class, “TE 299: Technology Education Practicum,” Technology and Engineering Education majors assist K-12 teachers with STEM activities for new or existing extracurricular programs at their schools. Upon completion of this course, students should be able to:

- Adapt and design components of selected extracurricular technology activities.
- Manage middle- or high-school students for successful long-term activities.
- Motivate learners through extracurricular technology activities.
- Promote technology education programs through extracurricular technology activities.
- Identify criteria for the evaluation of extracurricular technology activities.
- Provide a rationale for the use of extracurricular technology activities for students in middle- and high-school technology programs.
- Contrast the value of teacher-developed extracurricular technology activities with those overseen by associations.

The structure of both practicum courses affords multifold benefits in that the pre-service teachers enrolled in our program are provided with practical classroom experience while young public school students are being exposed to engineering and encouraged to consider the rewards of a college education at an early age.
HALS Academy – Partnership with CCSU

In fall 2007, a public middle school academy for identified gifted and high-achieving students, House of Arts, Letters and Sciences (HALS), relocated to a site near the university. The mission of the school is to address the unique needs of its students in order to develop their potential. The expectations for student learning have been tailored specifically to the needs of the student body and are based on research, district priorities, and accumulated data and feedback from stakeholders. Educational experiences at the academy provide students with a challenging, rigorous and relevant educational program to lead them to future success as responsible citizens and leaders in the twenty-first century.

The close proximity of this middle school academy presented an ideal opportunity for a partnership between educators from both institutions, which has been well received and is currently in its second year. Furthermore, 46% of the students who currently attend this academy are of Latino or African American heritage and 56% of all students are female; thus there is excellent potential to reach out to pools of talent which have historically been underrepresented in engineering. Since the practicum courses described previously require undergraduate field experience in both curricular and extracurricular settings, engineering activities were conducted both during normal classroom hours and as after school activities. For instance, in fall 2008 a new “bioengineering club” for sixth through eighth graders was formed, during which students learned about topics such as genetic engineering and prosthetic device design. Photographs illustrating some examples of university-middle school student interaction are provided in Figures 1 and 2 (please note that photo permission has been obtained).

The university/K-12 partnership has been equally successful in complementing curricular material during normal classroom hours. For instance, undergraduates enrolled in TE 155 during the spring 2008 semester taught computer-aided design (CAD) lessons to several eighth grade classes (examples of middle school student work are shown in Figures 3 and 4). By introducing CAD at this level, it was hoped that accelerated learners would be given a head start in high school and there is evidence to support that this goal was attained. The number of middle school students from the academy who enrolled in Project Lead the Way courses, which are offered as honors classes at the high school level, increased after their exposure to CAD through our partnership. Some parents have also since commented that this early exposure to CAD was very helpful to their children in their high school courses the following year. While anecdotal, this feedback lends further support to the value of this type of program.

Our partnership is distinctive not only because the practicum course component of our Technology and Engineering Education program at the university lends itself perfectly to successful and sustainable collaborations with K-12 schools, but also because of the mutually beneficial nature of the collaboration itself. In addition, by requiring the undergraduate students (pre-service K-12 teachers) to become familiar with and utilize the templates available through a NSDL database, it is hoped that K-12 engineering education will broaden its reach and continue to grow its resources.
Challenges and Strategies for Success

We encountered several hurdles during the implementation of our partnership. One of the first challenges we faced was simply attracting the middle school students to the new after school bioengineering club. In a recent installment in the Harvard Family Research Project’s series of evaluation briefs, “Issues and Opportunities in Out-of-School Time,” Lauver et al. describe barriers to the participation of youth in afterschool programs and possible incentives that may enhance recruitment and retention. Their research suggests the following as some key strategies for getting students into programs and sustaining their participation [4]:

- Assessment of student interest in various activities;
- Provision of a rich variety of experiences with peers and adults;
- Space and time for talking, food and fun;
- Field trips;
- Allow students some choice of activities;
- Flexibility with respect to enrollment and attendance; and
- Effective outreach to families about the program.

To reach out to the families of potential participants in our bioengineering club, parents were provided with information about the new program, including specific details regarding the bioengineering topics we planned to introduce. In addition, the middle school teacher devoted some time during class to discussion of the club with her students, with particular emphasis placed on the fun, hands-on nature of the planned activities, as well as the appealing aspects of the bioengineering profession such as its altruistic applications and collaborative work environment. According to the National Academies’ recent publication Changing the Conversation: Messages for Improving Public Understanding of Engineering [5], “Most current messages are framed to emphasize the strong links between engineering and just one of its attributes—the need for mathematics and science skills.” The authors remind us that “the medical profession does not market itself to young people by pointing out that they will have to study organic chemistry or by emphasizing the long, hard road to becoming a physician,” and they offer the following advice: “When promoting engineering, our appeal should tap into the hopes and dreams of prospective students and the public,” thereby “placing math and science, correctly, as just two of a number of skills and dispositions, such as collaboration, communication, and teamwork, necessary to a successful engineer.” This closely mirrors the approach we used when introducing our bioengineering club and its activities to students.

In addition to spreading the word about our new after school club and taking measures to avoid negative stereotyping, we also tried to bolster our recruitment and retention efforts by allowing our student participants as much ownership as possible of their projects. For instance, students were allowed to choose, when feasible, which activities to engage in and were often given the freedom to make design decisions within predetermined sets of constraints. Group work was met with enthusiasm, and served the added purpose of making it easier to teach students from three grade levels simultaneously since students would often help each other. Through a combination of these strategies, we maintained a fairly consistent attendance of approximately 25-30 students at each club meeting.
Whereas after school programs are voluntary, this is clearly not the case with regular classroom hours. While this may alleviate concerns about recruitment, it presents a unique set of challenges in terms of curriculum integration, standards alignment and scheduling constraints. To overcome these, we worked well in advance and with a single grade level (eighth grade) so that our pre-service teachers (CCSU students) could prepare lesson materials that would coincide with topics that the eighth grade students were learning about at that time.

**Successes and Lessons Learned**

While not surprising, it was readily apparent that middle school students behave very differently in after school programs than during regular classroom instruction. This necessitates all the more that attention is paid to key strategies for the recruitment and retention of students in these programs. Although we successfully executed some of these approaches, there is always room for improvement and in the future we hope to incorporate additional elements into our program such as field trips, including a trip to the CCSU campus, as well as guest speakers from industry and stronger assessment tools.

Requiring the pre-service teachers to conduct their lessons and activities with two separate but similar groups of middle school students worked very well both during and after school. This allowed time for the CCSU students to reflect on their teaching methods and make modifications accordingly. This technique also allowed for all HALS students to participate in every activity while keeping class and group sizes manageable.

**Conclusions**

Our collaboration can serve as a model for additional partnerships within our local district as well as for university and K-12 educators in the broader engineering education community. A sample course syllabus is attached to provide an example of how we were able to successfully integrate field experiences, which are required of our pre-service teachers, with classes and after school activities at a public middle school. Although ours is just one example of how such a partnership might take shape, it is intended to serve as a springboard for the development of additional models involving a wider range of grade levels and a broader scope of science, technology, engineering and math (STEM) topics, both at our university and elsewhere.

**References**

Figure 1. University and middle school students conducting activities related to prosthetic limb design.
Figure 2. Real-world examples of prosthetic limbs provided by a nearby prosthetics and orthotics certification program.
Figure 3. CAD drawing of Maglev design completed by an eighth grade student.
Figure 4. CAD drawing of various components completed by a different eighth grade student.
Figure 5. Sample syllabus from CCSU practicum course, TE 155, Integrating Engineering Concepts for K-8 Students. The syllabus presents an example of how university and middle school schedules can be coordinated to facilitate partnership.
Nine years ago, the engineering and technology program was created as an option in our comprehensive, urban high school. Over the years the program has grown from a concept with scattered engineering and technology activities to the current, small school version which offers eight different engineering and technology courses spread over four years. These include an introductory course addressing the State Comprehensive Technology and Engineering Curriculum standards, courses in Design, Manufacturing, and Electrical Engineering, multiple years of instruction in the AutoCAD software, as well as a senior capstone course.

Program Goal:
The goal of the secondary school program is more than providing a technical education. It also strives to enable all students to become capable learners. This is accomplished by specifically teaching students the skills that good students need, e.g. time management, organization, confidence, writing, reading, and group work. Students entering the university level need more than pure academic knowledge. The secondary school program works to teach students how to learn new information, work collaboratively and efficiently, and interact with and respond to a wide variety of texts.

Putting the Concept in Place:
Establishing the Engineering Technology Academy (ETA) within the school began with an interest among a few of the teachers in the school to address the new Technology/Engineering curriculum state frameworks that were released in 2000. These teachers worked with the school administration and partnered with engineering faculty and students at the local higher education institution, laying the foundational concepts that would be addressed. Actively working together, these partners developed a series of lessons and activities that met the early needs of the teachers to align their courses with the new curriculum standards. As the program became established, and the teachers used the materials which had been developed by the partner in the classroom, a bigger picture emerged of creating the ETA that would be a small school within the high school. The partners worked together to define what this could look like and to determine what the supporting pieces would be that each would offer.

Now the ETA is a well established program, providing engineering and technology instruction using multiple sets of curricular standards. The grade 9 courses primarily address the state’s comprehensive technology and engineering curriculum. This curriculum includes instruction on design principles, various energy and power technologies (fluid, thermal and electrical systems), and communication, construction, and manufacturing technologies. In grades 10 through 12, the courses cover more specialized curricula, governed by multiple vocational frameworks. The Engineering Technology Vocational Framework includes Health and Safety, Employability Skills, many varied Technical Skills (including but not limited to computers, electrical systems, applied ethics, design and modeling and production), Management and Entrepreneurship Skills,
and career pathways. The Electronics Vocational Framework requires a detailed analysis into analog and digital circuitry. Several courses rely on the Drafting Vocational Framework, focusing on computer aided design (Autodesk Inventor, AutoCAD), analyzing blueprints, dimensioning, and creating 2 and 3 dimensional models.

In the senior year capstone course, one of the major objectives is to integrate advanced mathematics and science into the engineering and technology education. The governing vocational document for this course requires a large number of embedded academic (i.e. math and science) skills within the vocational standards. In order to accomplish this, the class completes a project analyzing projectile motion. Instead of the traditional physics style laboratory where the equipment, materials, procedures and analysis directions are given, the students are tasked with developing their own methodology and tools. Students learn the necessary physics concepts of forces and motion (velocity, distance, acceleration, etc). They review the algebraic and trigonometric skills necessary to work with the formulas. Students then brainstorm, design, and build their own device, a device that produces reliable (i.e. consistent and repetitive) projectile motion. Students test their device, collecting numerous types of data, such as flight times, two dimensional trajectories and displacements, and initial velocities. Using computer technology, students analyze their results graphically. Lastly, students reflect on their work, reviewing data, completing redesigns, error analyses, etc.

**Data Shows the Success:**
The ETA is located in one of 4 major comprehensive high schools in an urban district. Approximately 1600 students are enrolled in this secondary school. 47% of the school population is female, 49% are minority students, 15% receive some form of special education services, and 47% are limited English proficient. The engineering and technology program within this secondary school serves 363 students. Within the ETA, 40% are female, 57% are minority, 8% receive special education services, and 41% are limited English proficient. When analyzing these and other demographic categories, it is evident that this program serves a representative sample of the school population. However, there are numerous statistics which differentiates the engineering and technology program’s students from the rest of the school. There is a 95% attendance rate for the program, compared to 92% for the entire school. 22% of the students in this program had disciplinary infractions, compared to 33% for the school. In the 2007-2008 school year, 81% of the grade 9 students were promoted to grade 10, compared to 71% for the school. Most telling is the pass rate for the state comprehensive exam. In the Mathematics examination, 78% of the program students earned proficient and advanced ratings, compared to 48% of the school. In the English Language Arts exam, 76% were proficient or advanced, versus 64% for the school.

**Structures to Support Students:**
Compared to the school, the students in the ETA program are proven to have fewer attendance and disciplinary issues, combined with stronger performances in numerous standardized examinations. Since the students statistically represent the demographics of the school’s population, there must be some pedagogical and methodological differences in the instruction provided in this program. In order for students to overcome challenges and obstacles, the secondary program has implemented three key strategies.
First, there is a consistent Grades 9 through 12 focus on using proven AVID (Advancement Via Individual Determination) strategies. Many of the secondary school teachers have received AVID professional development training. These teachers all use a common note taking method. This is done so there is consistency across courses and grades, allowing students to easily and quickly understand the teacher’s expectations and structure. The teachers collaborate among the disciplines (ELA, Mathematics, Engineering/Technology) to reinforce curriculum and align due dates of tests and projects so as to not overwhelm the students. Time management skills are stressed by assigning long term projects. There is a large focus on content area literacy by incorporating writing assignments and textual decoding methods in all courses.

Second, the program solicits feedback from the students. Two student groups were developed. The Student Researchers is a group of students representing grades 9 through 12. These students, as the name implies, conduct research among the student population. They analyze student performance, student attitudes and perceptions about the program, the reasons why students remain in the program, and investigate other areas of interest to the students in the program. The Youth Leadership Council works with the engineering and technology faculty directly. They serve as the student voice, acting as liaisons between the students and faculty. They recommend policy change, give feedback about teacher pedagogy and techniques, and organize student evaluations of the teachers. Many of these students are the program’s most vocal supporters. They promote the program at numerous community and school sponsored events.

Third, the secondary program has implemented an advisory program. Once a month, students meet with their academic advisor, who is a teacher, administrator, guidance counselor or academic support faculty member. At these meetings, students set and review academic and individual goals, discuss grade reports (issued every five weeks at this secondary school), analyze behaviors that support and detract from efficient use of time, and get to know the faculty members on a more personal level. Due to the scheduling of the program, grade level teachers all have the same prep period, allowing for common planning time. Teachers also use this time to meet as teams with individual students and their families to discuss concerns. This common planning time and advisory meetings allow for teachers to uncover and resolve potential conflicts quickly and without maximum disruption to the educational experience of the student.

Format of the Partnership:
The partnership between the local higher education institution and the secondary school continues to be close. Early input and guidance provided between the partners established the foundation of the program and many of the materials needed by the teachers. For example, groups of university students collaborated with the secondary school teachers to create and implement curricular units which become integrated into the secondary school courses. These collaborative projects provided a venue for continued dialogue between the partners. In addition, these long term projects produced instructional materials, laboratory activities, pre and post-test assessment data, and allowed for the university students to work directly with the secondary school students by functioning as the teacher within the engineering classes. To date, curricular units have been developed, implemented and refined in the areas of flight, robotics, digital circuitry, general design activities, and renewable energy. In addition, the university students have been guest lecturers in our classes and also are the facilitators of the Future Scientists and
Engineers Club. University faculty serves on the ETA’s Advisory Board, which meets regularly to discuss the current state of the program, review curriculum and instructional activities for age appropriateness and relevance to post-secondary education and/or working in the field, and seek input regarding the future plans of the program. In addition, teachers from the ETA serve on the university advisory board, which seeks input about what offerings or developments at the university would be most beneficial to the schools. Taking advantage of the proximity of the local higher education institution, our ETA classes regularly visit the university campus to conduct research at its central library, sit in on classes, receive tours of the campus and become exposed to the college atmosphere. Support for the teachers is provided through a variety of professional development opportunities run by the university. Many of the secondary ETA program teachers have taken advantage of these trainings which are centered on training secondary teachers how to deliver effective, age appropriate, challenging engineering and technology education.

**Suggestions for Emulation:**
The successes of this program can be implemented in other school systems. There are a variety of logistical (scheduling and staffing) changes this secondary school developed to foster these successes. Several suggestions and recommendations are summarized below, developed by the teachers in our engineering and technology program.

First, a relationship between the secondary and university level must be developed. The university faculty is best suited to suggest or tailor curriculum in order to ensure students are prepared for college. The university faculty also would serve as academic and methodological mentors for the secondary personnel. While close physical proximity would make this partnership easier to develop, it would be feasible to develop long distance relationships.

Second, the secondary school would need to recognize that engineering and technology education requires numerous projects, equipment, and consumables. A dedicated budget makes curriculum and project planning easy to accomplish. To ease this transition, it would be recommended that schools develop one course (or one year) at a time. Capital expenditures for equipment could be more feasibly spread over several years.

Third, involve the teachers, constructing the program from the bottom up. Include teachers in the decision-making and budgeting process. There should be uniform, teacher developed, laboratory rules regarding equipment use and safety protocols along with behavioral and academic expectations. Teachers support programs they helped to develop.

Fourth, the administration needs to support the secondary staff. Guidance staff needs to be made aware of the curriculum in the engineering and technology classes, any prerequisites coursework, and promotion policies. Historically, technology education classes become dumping grounds for troublesome or challenging students. With proper management and pedagogical training, this should not be an issue. In our school’s program, the AVID strategies, combined with consistent academic and behavioral expectations, reduced the incidence of disruptions.
Student A Sample of Work:

1. Objective
The high number of landmines in the country of Bosnia and Herzegovina has taken millions of lives over years. The work that is being proposed for the area will reduce the number of stake fragmentation mines, which is the most abundant type of mines found in the territory. The purpose is to create a safe environment for the population and regenerate agriculture in this part of Eastern Europe. In a greater scheme this work will be a gradual step against the use of antipersonnel mines.

2. Background:
The presence of landmines in Bosnia and Herzegovina is a result from the fall of communism in the early 1990’s. The Bosnia Herzegovina Civil War was started by the orthodox Serbian minority in the country because of its secession from socialist Yugoslavia. The war lasted from 1992 to 1995. Nearly 4% of the total territory of the country is affected by mines, which confirms Bosnia and Herzegovina as one of the most mine-affected countries in the world. As of June 2008 there are still around a million mines left in the ground.

This situation has already affected and is currently affecting all elements of society. The mines cause continuous terror to the population as hundreds of lives are taken every month. Prior to 1992 the territory of Bosnia and Herzegovina was mostly agricultural like all other communist governments. Industry has not developed tremendously in the country and there are still millions of people who depend on their land to secure food for their families. The biggest problem at this time is the limited funding in the widespread areas of low density mines where work can be very slow and frustrating.

In order to deal with the problem the area was surveyed and the type of landmines mostly used in the Eastern Europe in the early 90’s is stake
fragmentation mines. Their name is derived from their structure: they are placed on a stake above the ground and a trip-wire works as the trigger. The most common type of stack fragmentation mines is the PMR-2, which were originally manufactured by the Germans. They can kill anybody within 30 meters and can seriously injure within a radius of 75 meters. Tripwires are attached to the metal part, which makes the mines pull-actuated. Having a green color on the outside allows these mines to be hidden around bushes, or on grass. A small force of 2 N will set off the trigger, and the TNT that is located inside the mine will explode. The metal cap will break and little pieces disperse in air which accounts for the antipersonnel effect of these mines.

Prior to 2002 funds had been given for demining purposes in Bosnia and Herzegovina and many programs were initiated by foreign companies. Metal detectors are used in most areas, because they are cheap and accessible. Another old way used in the Bosnia area is by hand, using a knife at a shallow angle to remove the mine without actually pulling the trigger. New methods are available like employing radars, thermal neutrons, microwaves, and even satellites. The only problem with these technologies is how widely the mines are spread in the areas. After 2002 funds were decreased, and UNICEF is one of the only organizations to continue to work in demining in Bosnia and Herzegovina. Their program is called Mine Action Policy Development and it serves to educate the community who lives in the area about the local mine situation, how to spot a risky step or what to do if they are present in an explosion.

In order to have more successful demining of the Balkan Zone new solutions to the problem must be considered. A new method to be practiced for the stake fragmentation mines is to develop a device that lowers a magnet from the height of a helicopter to the location of the mine. The magnet would pull the tripwire of the PMR-2, causing it to explode without damage in personnel. Another way this explosion could be done is by designing a device that shoots small capacity bombs from a helicopter. Both these tactics require mapping of the zone with metal detectors to specify the location of a mine. Both require evacuation of the areas, with a radius of at least 75 m.

Another method that would get rid of these types of landmines is with the physical approach of a mine expert. A gun with a high temperature metal tip is needed, for the expert to go at the location of the landmine and melt off the trigger without creating any force to activate it. The mine would not have a tripping wire anymore, and the person would be able to remove it from the ground. However, the safety of this technique is low, because the person is close to the center of possible explosion. Also, because these PMR-2 mines many times are planted close to pressure activation mines, stepping in the area would not be safe.

Another solution would be to design a pendant that would connect the tripwire to a 100 m metal wire. A person needs to go about 1 m away from the mine using safety equipments that already exist. This expert would tie a knot on the tripwire, with no force acting to pull the trigger. A specially designed pendant would then go into the knot, to tie the tripwire with the long metal wire. The metal wire would have to be pulled from a further distance, to create the explosion and bring safety to the zone. These last two methods are more cost and time efficient.

In order to decide on a solution, the goals should be prioritized for the specifications of the situation in Bosnia and Herzegovina. The chart on Appendix 1 helps to break down these goals. The major focus for landmine removal was decided to be availability of parts and ease of use. Therefore the solution of this project should be something that can be easily produced and easily used. All the other features play a role too, but they are not as important.

To decide the solution to be used in Bosnia-Herzegovina a comparison of all proposed ideas should be made according to the rankings decided in the design goal matrix. Appendix 2
shows how each solution fitted to the circumstances of the region. Based on the score, the solution chosen is number four, involving a pendant and a metal wire.

3. Methodology
This solution fits perfectly to the geographic characteristics of Bosnia Herzegovina. Mines are very spread out in wide open areas, and this method allows the elimination of one mine at a time. In order to complete one mine removal Pendwi® device needs to be built, according to specifications given in Figure 3.

*Pendwi® is a registered trademark of Doherty Memorial Engineering.

Steps to remove a mine:
1. Determine the location with an existing metal detector
2. Evacuate the people from the area
3. Expert has the necessary parts: Pendwi and clamps, as well as existing anti mine safety equipment
4. Expert goes about 5 m away from the mine, to locate the tripwire.

Figure 3 Showing the Pendwi and how the method will function.
5. Expert clamps the tripwire lightly to the ground, applying force only to the sides, not directly on wire.

6. Expert makes a loop at the end of the tripwire

7. Expert opens the pendant

8. Expert places the loop inside the pendant head

9. Expert closes the pendant

10. Expert moves away from the area, at least 95 m.

11. Expert pulls the end of the steel wire

12. Trigger activates

13. PMR-2 explodes, along with any small bombs located inside the ground around it.

Estimated time to remove one mine is 10 minutes. If the work is continue for 365 days. Because there is around 100000 mines present, in order to complete the work in 1 year, 274 mines should be removed per day. This is a high number, but if 27 groups of 3 mine experts were assigned, each group would be responsible for a rate of demining of 10 per day. The cost to get rid of one mine is estimated to be about $15, calculating payment made to people. Therefore, the total cost of the project is around $15,000,000.

The effects that this solution will have will make up for the damage to be caused by explosions, as well as its cost. Once an area is cleared of mines people will feel safe to use the land for agriculture and the economy of the country will start to shape once again. If work progresses satisfactorily then more funds will be given for demining purposes all around the world, so that every child grows up without fearing that his or her life can end any minute from military remains in the ground.

Bibliography


Appendix 1

Design Goal Matrix

Scale:  
0 – not as important  
½ – equally important  
1 – more important

Ranking:  
8 – most important  
1 – least important

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<th>Safety Improvement</th>
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Appendix 2

Solution 1: With Magnet
Solution 2: Bomb Shooting
Solution 3: Melting
Solution 4: Pendant

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***Ranking of the design goal matrix was multiplied by a number 1-5, (5 being the highest) decided on how each solution fitted each criterion.
Student B Sample of Work:

An example of the interdisciplinary work done by the engineering and technology students.

Students chose two aspects or fields that interested them. They then “bridged them” together, as a metaphor for learning. Students conducted Internet and print research, created scaled drawings of the bridge and other technologies, developed persuasive writing papers, analyzed the mathematical and scientific principles involved, and created a visual presentation. Students then discussed their work with other students, teachers, administrators, parents, guardians and many other community members.