AC 2010-1770: BUILDING A COLLABORATIVE K12 PARTNERSHIP

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Building a collaborative K12 partnership

Abstract

TechSTEP, Cyber Discovery, and NASA-Threads are partnerships between K12 schools and Louisiana Tech University that lead to an improvement of high school student achievement in mathematics and science. These partnerships result in better prepared students entering science, technology, engineering, and mathematics (STEM) programs at the university level. Teachers from regional high schools and university faculty from STEM disciplines work together through multiple collaborative projects. Collaborators (including the authors) come from a broad range of disciplines: engineering, education, mathematics, and the liberal arts, as well as K12 teachers and administrators.

The collaborative partnerships developed between area high schools and Louisiana Tech University ensure that the curriculum and education programs are challenging but appropriately targeted for high school students. These projects reach schools which have differing economic and social demographics. Thus the partnerships provide for the development of a robust program that can be implemented in schools regardless of size, location, or economic status of the community.

The latest partnership, NASA-Threads, builds upon the u-Discovery model by providing professional development in the context of curricular design in physics and engineering. Teaching fellows, along with faculty from the university, spent the summer completing the initial development of this new curriculum. Following this intensive curriculum development phase, the three core partner schools implemented the pilot curriculum. By establishing a truly collaborative partnership, the curriculum is appropriately revised throughout the pilot year. In the next academic year, the program will expand to include 30 teachers from 15 schools. This paper presents a model for collaborative partnership between K12 schools systems and universities.

Introduction

According to the National Science Board's (NSB) Science and Engineering Indicators 2008[1], enrollment in engineering and science undergraduate programs is expected to continue to rise because of a continued increase in the college-age population; but the report also indicates that, of those students who do enroll in engineering and science programs, only about 60% earn an engineering or science degree within six years. Salary data collected throughout the last century indicate increasing demand for engineers and scientists in the workforce. Clearly, there is a

continued need for increased enrollment and retention in science and engineering. In The Science *and Engineering Workforce: Realizing America's Potential*, the NSB strongly recommends national-level action to provide an adequate number of science and engineering graduates to ensure competitiveness in the ever-changing global economy[2]. Moreover, there is a critical need for partnerships between universities and K12 schools to increase the mathematics and science abilities of high school graduates – preparing them for any career path, particularly for STEM disciplines.

In addition to the quantity of engineering and science graduates, many studies have focused on the qualities needed of these graduates by today's society. Not only do they need technical fundamentals, but they also need to be able to integrate technical knowledge into real-world situations[3]. Many pre-engineering outreach/recruitment programs are centered on hands-on projects, which is one of the most important characteristics of our programs. However, while 77% of K12 engineering programs in the United States focus on students, only 46% focus on the teachers[4]. All of the K12 programs that are a part of our Integrated STEM Education Research Center (ISERC) target both high school students and teachers. While engaging high school students in relevant and interesting engineering design projects has had an immediate impact on increasing STEM enrollments at our university, we believe long-term impact is more likely to result from the interactions and relationships developed with high school teachers.

TechSTEP

Our TechSTEP program follows a professional development model that engages high school teachers with the aim of giving them an opportunity to lead students through hands-on engineering projects. We refer to this professional development model as u-Discovery (Understanding through Discovery)[5], and we propose that this model can be readily adapted by other universities interested in developing meaningful K12 relationships. Currently, TechSTEP has three different projects which are rotated on a three-year cycle. Each project shares the common u-Discovery approach.

The u-Discovery model consists of three phases, although there is considerable overlap among these phases:

1. **Initiate Understanding** by leading the learner on a tour through a real world system.
2. **Broaden Understanding** by exploring related content and expanding learners' knowledge of the subject matter.
3. **Deepen Understanding** in the topic area through additional content and a weekend challenge.

For more detailed explanation of the u-Discovery model, see [5].

Perhaps the most critical element that cuts across all phases of the u-Discovery model is collaboration. University faculty from Engineering, Science, and Mathematics work together to develop all activities, lessons, and materials; and then they jointly facilitate the Teacher Workshops. This collaboration emphasizes to both teachers and students the importance of real connections inherent in the problems we present. Also, each set of teachers (usually three teachers from each school) is paired with a college student mentor for every Teacher Workshop and Discovery Weekend. When teachers have content or technical questions, they have immediate access to the mentor working with them. When their students come to campus, they have the same mentor providing seamless and coherent project facilitation for their school's team. Finally, we encourage peer-to-peer collaboration. Every project and most activities have a team component where teachers and students have to work together to solve a problem, prototype a design, or collect data.

This collaborative approach enables us to function as a truly interdisciplinary team of university faculty, high school teachers, and college student mentors as we engage the high school students during the Discovery Weekends. As a result teachers are much more confident with the technical content and are much better prepared to incorporate fundamental concepts into their own classes.

Cyber Discovery

The Cyber Discovery camp is a professional development project that also uses the u-Discovery model. The project expanded this model by incorporating a week-long, total immersive summer component and integrating the humanities and STEM disciplines. Once again, Teacher Workshops, led by a university faculty team, illustrate how math and science topics at the foundation of cyberspace science interplay with political and social issues in our society.

Cyber Discovery was developed by a team of math, science, engineering, and liberal arts faculty. The primary goal is to help teachers and students become better cyber-citizens who help, rather than hinder, security efforts by making them aware of the benefits and dangers of cyberspace. This residential camp experience in the summer exposes student participants to multiple topics of cyberspace including: history of cyberspace, ethical and social issues, applications, and the need for and use of security in cyberspace.

In preparation for the week-long camp, the Cyber Discovery team developed workshops for participating teachers held on two weekends prior to the camp. The goals were to demonstrate the integration of fundamental topics in math, science and the humanities in the context of cyberspace. Our experience through TechSTEP has shown us that these applications can be

integrated into high school classes and improve interactions between teachers and students throughout the school year.

Each of the participating high schools sends two teachers and six students to the Cyber Discovery camp. Teachers from the schools select students who have shown an aptitude for math/science or the humanities. Teachers are urged to select student teams that balance academic disciplines with roughly half of the team having interests in science/math and the other half in humanities.

NASA-Threads

Building on our partnerships with K12 systems in TechSTEP and Cyber Discovery, NASA-Threads integrates fundamental science and mathematics courses with engineering applications and appropriate use of technology into a physics curriculum targeting the junior/senior year of high school. The threads of this curriculum include fundamentals, technology, communication, and NASA applications. These threads are continually linked together through the use of hands-on projects throughout the physics curricula. The fundamentals, which are grouped into blocks of similar topics, provide the backbone of the educational experience. NASA applications are strategically introduced to provide timely hands-on reinforcement of fundamentals and the progressive development of technical knowledge and skills.

NASA-Threads is our most recent partnership with K12 schools that focusing on improving high school student achievement in mathematics and science. In addition to building on TechSTEP and Cyber Discovery, the NASA-Threads curriculum is patterned after Louisiana Tech University's Integrated Engineering Curriculum[6]. This integrated engineering curriculum includes a sequence of hands-on courses throughout the freshman year using a multi-course project to provide seamless integration of mathematics, science, and engineering topics. We have taken a similar approach by developing a new, challenging, interdisciplinary junior/senior-level high school curriculum which provides for the development of a technology-enabled, project-based curriculum for high school students.

The three partner pilot schools involved represent a healthy diversity in terms of student demographics. RHS is a relatively large high school, BHS is a small rural school, and LHS is a large high school in a metropolitan area. The Teaching Fellows from these partner schools, serve as guides to ensure that the curriculum is challenging but appropriately targeted for upper-level high school students. Moreover, this project reaches schools which have differing economic and social demographics and aids in the development of the robust program that can be emulated in schools regardless of size, location, or economic status of the community. After the pilot year

with the three partner schools, NASA-Threads will expand to include 15 schools during the 2010-2011 academic year.

Connections Between Programs

Establishing and building relationships with individual teachers and administrators in school systems throughout our region is the most critical component to all of our Integrated STEM Education Research Center's K12 efforts. Our initial TechSTEP program laid the groundwork for building trust among the K12 partners. This close collaboration gives school systems a greater confidence for allowing university faculty to implement new, rigorous, and innovative programs with the teachers and students.

In implementing any new program, the challenges faced by high school teachers include affordability, practicality, rigor, state content standards, and ease in implementation. Moreover, similar challenges are faced at the administrative level and must be addressed before they can consider implementing curriculum or deciding to have their teachers and students participate in a new program. Our experience in project-based learning and our close personal relationships with K12 teachers and administrators in the region has led to strategies that alleviate many of these concerns. As a result, schools can focus their attention on the remaining challenges related specifically to student learning in the classroom.

One of the primary goals of all of our K12 programs is to improve teacher self-efficacy in presenting STEM material. We believe that true long-term impact on students comes from the day-to-day interaction with their teachers. By improving teachers' confidence, we can improve student performance. At first glance, it appears that each of our programs are centered on students. However, they are actually focused on teachers. Our experience has shown that students provide the motivation for the teachers. The primary goal is to engage the teachers in STEM content by working together to motivate their students to consider the relevance of and connections with the high school science and mathematics courses they are studying. By working in collaborative teams, the teachers gain increased understanding of these same connections and are better prepared to answer the "Why do I need to know _____?" questions from their students.

Each of our programs described above provides a mechanism for improving teacher confidence with STEM material, and additionally provides an outlet for implementing the material with the students. In TechSTEP, we bring in the teachers for workshops prior to Discovery Weekends. In these workshops the teachers complete the same projects and dive deeper into the STEM

fundamental topics with guidance from university faculty. In the following Discovery Weekend, teachers and university faculty collaboratively lead the student teams through the projects.

Building on this model, Cyber Discovery teachers attend Weekend Workshops where the over-arching theme of cyber science is presented by university faculty from both STEM and the Liberal Arts. Teachers are shown how cyber is inter-woven into all aspects of our culture. STEM and sociopolitical topics are presented so that the teachers develop a broad view of cyber. The teachers and university faculty together lead student teams during the week-long immersive Cyber Discovery camp. The result is that the teachers provide the continuity between all of the topics that are presented throughout the week.

NASA-Threads focuses on training teachers to implement a year-long physics curriculum. Teachers are brought in for two-week long professional development summer workshops, as well as academic year weekend workshops. These workshops focus on building confidence with the projects and fundamental topics. The teachers then implement the curriculum with their students throughout the academic year and work with the university faculty to further refine the curriculum. Primary challenges related to student learning with new curricula include the development of lesson plans and notes from trusted sources as well as the experience of isolation associated with teaching a single course in a school. Some of the strategies include the development of master notes (by university faculty and K12 teachers) through continual collaboration with the teachers both in person and electronically. Through the NASA-Threads web portal (www.nasathreads.com) university faculty provide master notes as well as additional resources for teachers.

Results

TechSTEP

Each of the programs described above is designed to engage high school teachers and their students in challenging engineering design projects that demonstrate applications of high school level mathematics and science. For TechSTEP, the immediate goal is to encourage the students impacted to pursue STEM degrees in college. However, the long-term (and we believe more important) goal is to provide teachers with a more thorough understanding of how to connect their classroom topics to engineering and science, thereby extending the impact of TechSTEP to all students in their classes. To date, the TechSTEP program has directly impacted 8 high schools, 24 teachers, 163 high school students, and 14 college student mentors. It has indirectly impacted over 1,000 high school students.

All data collected to date show an overwhelmingly positive response to the program from both students and teachers. Over 75% of student participants in TechSTEP have indicated that the program helped them decide to pursue a STEM degree in college. Figure 1 shows responses from high school teacher participants. A few of the questions most relevant to this paper are identified below:

Q9. I have a greater sense of confidence in taking risks to change the content and the methods of teaching mathematics /science.
Q12. I have examined and revised my classroom practices to include information and student projects involving STEM careers.
Q14. There will be an ongoing collaboration between my school and Louisiana Tech in the STEM disciplines beyond this project.
Q18. I believe that the LaTechSTEP Discovery Weekend Program will bring about change that will encourage more students to enter mathematics, science, or engineering professions.

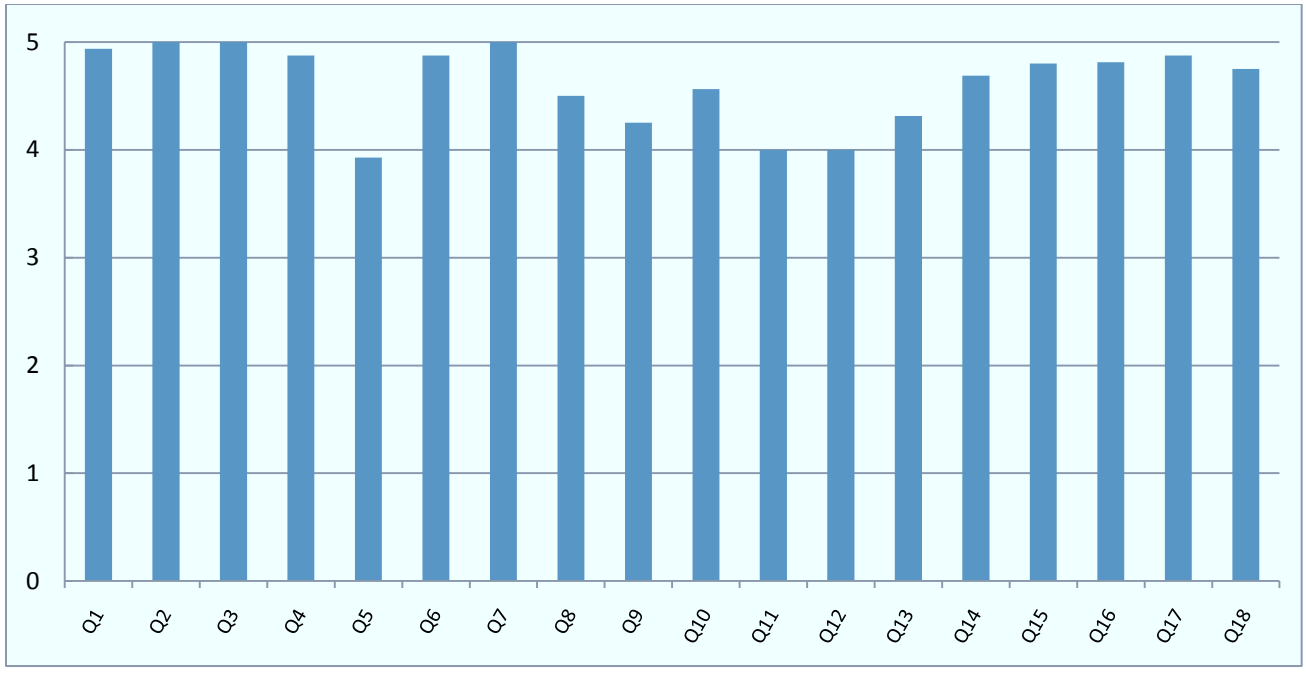

Figure 1. Teacher Responses from TechSTEP Program (0 = Strongly Disagree, 5 = Strongly Agree)

Teacher participants were also asked to provide written responses to several additional questions. Perhaps the most important of these questions was *"As a result of* TechSTEP, what has changed *in your classroom?"* All responses were very positive. The following is a sample of these responses:

*"*It has changed my teaching style completely. It is the best instruction for teaching that I have *ever received!"*

"I do more hands-on activities. Every activity I do makes class more interesting and learning *more fun."*

"I am incorporating activities for a deeper, better study of vectors."

"My students who are attending TechSTEP have shown their classmates what we've been doing. They now see how we actually 'use this stuff'!"

"Making sure my students understand that all they do now is connected to what they do in the *future."*

Cyber Discovery

During the summer of 2008, 30 high school students and 10 teachers, from 5 schools throughout the region participated in the summer camp. In the summer of 2009, 48 high school students and 16 teachers participated. Similar to TechSTEP, comments from teachers regarding this professional development experience have been overwhelming. As a result of the impact of the first pilot program in 2008, the U.S. Department of Education has funded an expansion of the program in 2009 at both Louisiana Tech University and to a partner university in the region. At our partner university, 36 high school students and 12 teachers participated in a Cyber Forensics camp following our u-Discovery model. Further expansion of the model is anticipated through grant funding in 2010 to include four universities in north Louisiana. Some of the teacher comments on the Cyber Discovery project are:

"This is amazing! My English and History students tell me that they now see why they must learn the science and mathematics, and the 'computer science' students now understand why politics and history are important."

"The impact of Cyber Discovery on our school has been phenomenal. The students who participated in 2008, as freshmen, are now the leaders in the school.*"*

One student wrote:

"This program is great for those who are technological and creative. It's the perfect learning experience. I would love to come back!"

NASA-Threads

Our NASA-Threads program has similar goals as TechSTEP; however, the approach is different. Students are introduced to engineering design concepts through the NASA-Threads curriculum rather than through weekend workshops. Student responses to the curriculum are shown in Figure 2 and in the student comments that follow. A few of the most relevant questions are identified below:

Q1. I have a better understanding of what engineering is now that I am in the NASA-Threads course.
Q2. I find science more interesting in the NASA-Threads course than I did in other science courses.
Q5. My critical thinking skills were better developed through the NASA-Threads course.
Q8. I feel confident in solving fundamental physics problems because of the NASA-Threads course.
Q11. I am confident in my ability to perform well in higher education due to the NASA-Threads course.
Q12. Because of the NASA-Threads course, I am more interested in pursuing higher education in a Science, Technology, Engineering, and Mathematics based field.

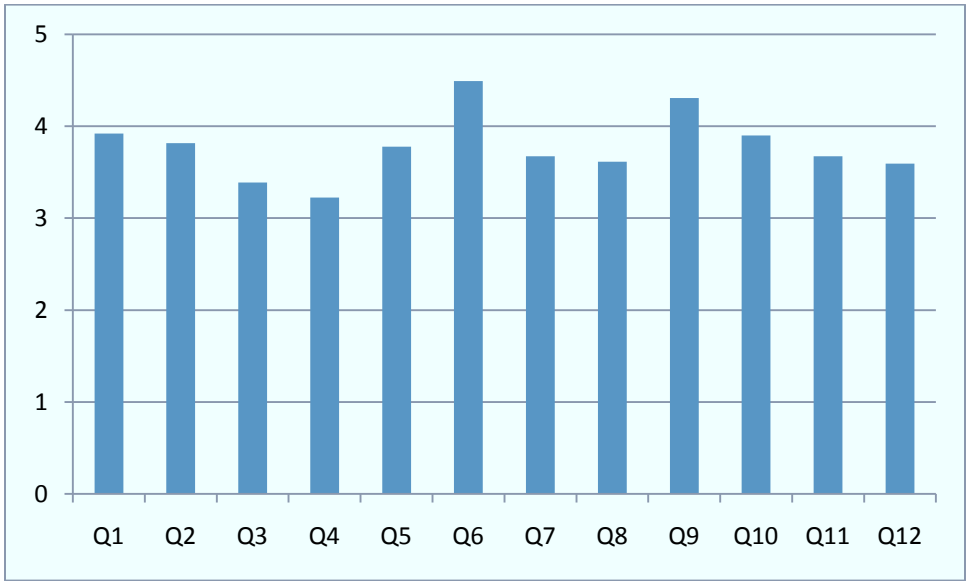

Figure 2. Student Responses from NASA Threads Program (0 = Strongly Disagree, 5 = Strongly Agree)

Student comments about NASA-Threads:

"The project-based curriculum helps give me a better understanding of the application of *physics and mathematics, which entices me to follow a career in engineering."*

"Because of this course, I feel I am more likely to study engineering in college."

"I like being able to use my hands to understand engineering."

"The NASA-Threads curriculum has broadened my view of science and engineering. I look at it in a different way and even though I'm not interested in pursuing the science field, I have a *greater appreciation for it."*

"The NASA-Threads curriculum has shown me how STEM concepts can actually be useful instead of just learning a concept for a test. I enjoy the challenge the curriculum provides *because in other classes there are fewer opportunities to critically think."*

Teacher comments about NASA-Threads:

*"*Hands-on real world projects inspire students more than textbook/problem based curriculum. Robots and video applications are more relevant than old style Physics labs.*"*

*"*It [NASA-Threads] has given us a model for how to provide a really relevant, project-based curriculum that is also rich in the fundamentals. The curriculum connects the technology that students will need to know with the underlying principles in math and science. NASA-Threads has really opened our eyes to what can be done when you step away from traditional textbook and lab exercises and teach in a way that is more collaborative, hands-on, and project-based.*"*

*"*This course allows us to integrate Physics and Engineering in ways that are applicable to the real world. This NASA-Threads Physics course takes the "plug-n-chug" out of physics and forces students to understand the underlying concepts in order to complete the projects.*"*

Clearly, all three of these programs are very successful. Plans are being developed to sustain the most successful elements of each program with support from area industries and other entities, such as the Cyber Innovation Center in Bossier City, Louisiana. Our experiences with these programs has significantly impacted the approach we take toward high school recruiting, moving us toward more direct interaction with students and teachers rather than relying exclusively on College and Career Fairs and campus visits.

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