

2006-2500: PREPARING FOR EMERGING TECHNOLOGIES: A GRASS-ROOTS APPROACH TO ENHANCING K-12 EDUCATION

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Preparing for Emerging Technologies: A Grassroots Approach to Enhancing K-12 Education

Abstract

In the summer of 2004, Tennessee Tech University joined a partnership that included five, mostly rural, Tennessee county school systems to assist them with the development and implementation of a program called “Preparing for Emerging Technologies.” The primary objectives of the program were to:

- enhance the rigor and relevance of existing K-12 curricula by incorporating content from emerging fields of technology, including nanotechnology, biotechnology, information technology, and others;
- encourage students to pursue careers related to science, technology, engineering, and mathematics (STEM); and,
- develop a better-prepared workforce in order to attract new industry and business to the partner counties.

The efforts of this group resulted in a series of three professional development workshops for teachers and two summer enrichment programs for high school students. The first workshop focused on the need for including the emerging technologies in the existing curricula, the second on providing teachers with the background information and materials needed to introduce the emerging technologies in their classrooms, and the third on providing teachers with the knowledge and materials needed to prepare specific lesson plans. A unique feature of these workshops was that teachers from all curricular areas were encouraged to participate, including English, history, and social studies. The summer enrichment programs were designed to provide high school students with exposure to the emerging technologies, encouragement toward STEM-related careers, and a college experience. More than thirty different organizations representing government, industry, and education contributed to the summer enrichment programs, providing tours, demonstrations, lectures, and hands-on activities in emerging technology research laboratories and industrial facilities located throughout the State of Tennessee. This paper presents program details, lessons learned during the first year, results of participant surveys, and plans for future programs.

Introduction

In the late summer of 2004, Tennessee Tech partnered with Columbia State Community College, Motlow State Community College, and school systems from Giles, Lawrence, Maury, Warren, and Williamson Counties to assist with the development and implementation of a program called “Preparing for Emerging Technologies.” The primary objectives of the program were to:

- enhance the rigor and relevance of existing K-12 curricula by incorporating content from emerging fields of technology, including nanotechnology, biotechnology, information technology, and others;

- encourage students to pursue careers related to science, technology, engineering, and mathematics (STEM); and,
- develop a better-prepared workforce in order to attract new industry and business to the partner counties.

Although the partner counties are mostly rural in terms of land development, they all have a significant industrial and business presence, including major facilities such as Saturn’s Spring Hill plant in Maury County. To some degree, all of the partner counties have experienced job losses in recent years due to outsourcing of manufacturing work and factory closures. As a result, the partner counties have engaged in a variety of economic development efforts aimed at attracting new business and industry, and all realize the importance of having a well-educated and technically-skilled workforce.

The idea for the “Preparing for Emerging Technologies” program originated with the vocational education directors from the partner counties. The vocational education directors, who all knew each other from previous work with statewide vocational education associations, began meeting to explore ways to not only provide their students with the education and technical skills needed for future jobs, but to also excite their students about the prospects of STEM-related careers. Although each of the five counties ultimately developed a slightly different plan, they all agreed on a number of key points:

- Curricula content based on emerging fields of technology, such as nanotechnology, biotechnology, and information technology, would provide students with knowledge that was relevant to future jobs. Existing curricula contained little, if any, content related to the emerging fields of technology.
- Curricula content based on emerging fields of technology could help attract students into STEM-related careers because it directly relates to technology the students see in the news and to the technology in their lives.
- Emerging fields of technology tend to be interdisciplinary in terms of the traditional fields of science and mathematics, providing students with a realistic view of how content from many areas of study must be integrated and used together. The interdisciplinary nature of the emerging fields also provides opportunities to increase the rigor of K-12 curricula by challenging students to use knowledge gained from a variety of courses.
- Since almost none of the current teachers have any background in the emerging fields of technology, professional development training would be critical to the success of any program.
- Integration of the emerging technologies content into non-STEM courses, such as English and social studies, could reinforce the material and generate additional interest in STEM-related fields.

Using these key points as guidelines and pooling their limited resources, the five counties formed a partnership and worked to develop a program that would be mutually beneficial to all of them. The “grassroots” efforts of this group resulted in a series of three professional development workshops for teachers and two summer enrichment programs for high school students.

“Preparing for Emerging Technologies” Teacher Workshops

Three one-day workshops were held during the 2004-2005 academic year:

- **Introductory Workshop (September 2004, Holiday Inn, Brentwood, Tennessee):** The first workshop focused on the need for including the emerging technologies in K-12 curricula. Attendees included more than 100 teachers, school administrators, government officials, and industry representatives. The program included a keynote address by Dr. Willard Daggett from the International Center for Leadership in Education, several presentations highlighting workforce development issues, and presentations tailored for teachers in selected K-12 curricular areas, including mathematics, the sciences, agriculture, health science, English, social studies, and career/technology education.
- **Background Knowledge Workshop (January 2005, Saturn Training Center, Spring Hill, Tennessee):** The second workshop focused on providing teachers with the background information and materials needed to introduce emerging technologies content in their classrooms. Over 80 teachers and school administrators attended. The program included a general session featuring Dr. Richard Haglund of the Vanderbilt Institute for Nanoscale Science and Engineering and breakout sessions for different curricular areas.
- **Methods and Materials Workshop (April 2005, Tennessee Technological University, Cookeville, Tennessee):** The third workshop focused on providing teachers with the knowledge and materials needed to prepare specific lesson plans for their classes. Over 80 teachers and school administrators attended. The program included presentations by Tennessee Tech faculty and a tour of research facilities. Attendees also received a CD containing specific resource materials related to each of the presentations. A display of commercially available educational materials in the emerging technologies was also provided.

An interesting aspect of this program was that teachers from all curricular areas were encouraged to attend the workshops. Most of the partner counties intend to incorporate emerging technologies content into areas such as English and social studies, as well as the sciences, mathematics, and technology courses.

A brief survey was conducted at the close of each workshop. The survey results from the first two workshops indicated that, overall, the participants were satisfied with the content and quality of the programs. However, survey comments collected from the first two workshops indicated that the teachers wanted materials and lesson plans that they could take directly to their classrooms. Teachers were enthusiastic about the use of the emerging technologies, but most did not feel they had the time or expertise to develop their own lesson plans and materials. This feedback was used to develop the program for the third workshop, held on the Tennessee Tech campus. The objectives of the TTU workshop were to

- provide effective materials and methods for increasing student interest in emerging technologies, and
- increase teacher knowledge of emerging technologies.

TTU workshop sessions included:

- “Nanotechnology for the 21st Century” – an overview of the field of nanotechnology, including demonstrations of atomic force microscopy, shape memory alloys, and ferrofluids. (This presentation was designed to introduce nanotechnology in high school math and science classes. Teachers received a complete script and all presentation materials.)
- “We All Live in a Watershed – Using Environmental Issues to Teach Science and Engineering Relevance” – a breakout session for agriculture, chemistry, biology, and science teachers.
- “Graphical Information Systems in Education” – a breakout session based on GPS/GIS technology for information technology, computer science, and social studies teachers.
- “Operations Research – Using Mathematics to Make Decisions” – a breakout session for mathematics teachers.
- “Technical Writing” – a breakout session for English teachers
- a tour of TTU engineering and science research facilities

As previously mentioned, attendees also received a CD containing specific resource materials related to each of the presentations.

Table 1 contains a summary of the survey results for the TTU workshop. The results indicate the workshop was successful in achieving the stated objectives. Comments collected with the survey indicated the teachers were pleased with the content and quality of the program, but reiterated the need for specific lesson plans and readily usable materials at future workshops.

Table 1: Summary of Survey Regarding Methods and Materials Workshop Objectives

Workshop Objective: The workshop ...	Average Response (Standard Deviation)
(1) provided effective materials for increasing student interest in emerging technologies (ET).	5.52 (0.57)
(2) provided effective methods for increasing student interest in ET.	5.45 (0.62)
(3) helped increase my knowledge of ET.	5.70 (0.47)
(4) duration was sufficient to prepare me for increasing student interest in ET.	5.06 (0.79)

(Response Scale: 6 = strongly agree, 5 = agree, 4 = slightly agree, 3 = slightly disagree, 2 = disagree, 1 = strongly disagree)

President's Academy for Emerging Technologies

The partner counties also wanted to provide a summer enrichment opportunity for their students. At their request, Tennessee Tech developed the President's Academy for Emerging Technologies, an academic program for high school students designed to stimulate and build interest in science, technology, engineering, and mathematics. The academy objectives were to

- improve students' knowledge of emerging technologies,
- improve students' knowledge of careers in the emerging technology fields,
- improve students' knowledge of college in terms of academic demands,
- improve students' knowledge of college in terms of life on campus, and
- have fun.

The Academy curriculum was based on the emerging technologies, including:

- nanotechnology,
- biotechnology,
- information technology,
- fuel cell technology, and
- supporting areas, such as robotics, operations research, and technical communications.

A unique group of education, government, and industry organizations supported the Academy program. These partners provided tours, demonstrations, lectures, and hands-on activities in emerging technology research laboratories and industrial facilities located throughout the State of Tennessee. The seven core partners included:

- Tennessee Technological University
- Oak Ridge Associated Universities (tour of Tech 2020 and Oak Ridge National Laboratory facilities, lectures by distinguished researchers)
- Chattanooga State Technical Community College (support for Chattanooga trip, Challenger Center mission simulation activity)
- New Economy Institute (presentations and tours)
- Vanderbilt University (tour of Vanderbilt Institute for Nanoscale Science and Engineering)
- Arnold Engineering and Development Center (tour)
- University of Tennessee Space Institute (presentation and tour)

Supporting partners included thirteen additional education, government, and industry organizations. The program activities provided by the various partners helped to reinforce the classroom and lab activities conducted on campus and provided students with real world examples of how the emerging technologies are being used.

The schedule for a typical day on campus is shown in Table 2.

Table 2: President’s Academy for Emerging Technologies – Typical Daily Schedule

TIME	ACTIVITY
6:15 a.m.	Wake-up & Personal Time
7:00 a.m.	Breakfast
8:00 a.m.	Technical Communications
9:00 a.m.	Chemistry & Water Quality Science
10:30 a.m.	GPS & GIS Technology
12:00 a.m.	Lunch
1:00 p.m.	Materials Science & Fuel Cells
2:30 p.m.	Operations Research & Robotics
4:00 p.m.	Free Time
5:00 p.m.	Dinner
6:00 p.m.	Free Time, Homework, Fitness Center
8:00 p.m.	Special Activity
9:00 p.m.	In Dormitory Curfew
10:30 p.m.	In Room Curfew

The first academy session was hosted in June 2005, at the request of the partner counties. The participating students were selected by the county school systems and included students from grades 9 through 12. This session was funded primarily by the participating school systems and NASA Space Grant funds that provided scholarships for ten female students. Sixteen female students and 25 male students attended for a total of 41. The first session was six days in duration and included a one-day trip to Vanderbilt University.

A second academy session was conducted in July 2005, to investigate the potential of proposing the academy as a future Governor’s School, a series of summer enrichment programs for high-achieving students funded by the State of Tennessee. This session was advertised State-wide and 32 participants were competitively selected from 65 applicants. Participants included 15 female and 17 male students in grades 10 and 11, representing 18 different counties. The second session, funded by Tennessee Tech, was 13 days in duration and included a two-day trip to Chattanooga and one-day trips to Oak Ridge and Tullahoma.

Both sessions of the President’s Academy were surveyed with identical statements regarding the academy objectives. The results, shown in Table 3, indicate that both sessions were very successful in meeting the stated objectives. Average responses show a positive result for all objectives in both sessions, with the exception of the third objective in session #2. In both sessions, all surveyed students responded with either “agree” or “strongly agree” for the first two objectives. Statistical differences, at the 0.05 level of significance, were observed for the third and fifth objectives.

The academy program attempted to provide students with a college experience in terms of the typical academic demands placed on a freshman student. The short duration of the academy sessions and the variety of material incorporated into the program made this extremely difficult to achieve. Several academy faculty members commented that the academy program likely did

not meet this objective. As a group, the students in session #2 were academically stronger than those in session #1, and several of the students in session #2 had previously completed college-level courses. As a result, the students in session #2 were probably better prepared to judge whether or not the academy program was equivalent to college-level work in terms of academic demands.

Table 3: Comparison of President’s Academy Sessions Regarding Academy Objectives

Academy Objective: The President’s Academy ...	Session #1 Average Response (Std. Dev.)	Session #2 Average Response (Std. Dev.)	P-value for Two-sample t-Test Assuming Unequal Variances
(1) improved my knowledge of emerging technologies (ET).	3.429 (0.502)	3.531 (0.507)	0.204
(2) improved my knowledge of careers in the ET.	3.486 (0.507)	3.531 (0.507)	0.357
(3) improved my knowledge of college in terms of academic demands.	3.286 (0.572)	2.969 (0.647)	0.019 (Significant Difference)
(4) improved my knowledge of college in terms of life on campus.	3.429 (0.608)	3.469 (0.621)	0.395
(5) was fun.	3.486 (0.561)	3.844 (0.369)	0.001 (Significant Difference)

(Response Scale: 4 = strongly agree, 3 = agree, 2 = disagree, 1 = strongly disagree)

The higher response of session #2 students for the fifth objective may be explained by a number of factors:

- Session #2 was twice as long as session #1, providing more time for the students to get to know each other and form friendships.
- Session #2 included several recreational activities on the middle weekend.
- Session #2 utilized a new dormitory for student housing.
- The students in session #2 may have been more academically focused and, therefore, may have had more fun learning. This conclusion is also supported by survey responses regarding what the students liked best about the academy. Thirteen out of 32 of students in session #2 responded with answers that included “learning” as one of the best things about the academy. Only two of 35 students in session #1 had a similar response.

The more extensive survey instrument used for session #2 provided additional data for program assessment and some comparisons between female and male student responses. The results are shown in Tables 4 and 5. Table 4 summarizes responses to questions regarding the impact of the program on the student’s interest in STEM fields. Raw data shows that 27 students reported either an increase or significant increase in interest in the STEM fields as a result of attending the

academy. Five students reported no change in interest, and no students reported a decrease in interest. Table 4 also compares female and male responses, with a statistical difference at the 0.05 level of significance for question #5. This indicates that the female students reported, on average, a lower level of increase in their interest in STEM fields than the male students reported. As a result of this indication, additional analysis was conducted in an attempt to identify specific items of program content that may have caused the differences.

Table 4: Effectiveness of President’s Academy Session #2 Regarding STEM Interest

Survey Question	All Average Response (Std. Dev.)	Female Average Response (Std. Dev.)	Male Average Response (Std. Dev.)	P-value for Two-sample t-Test Assuming Unequal Variances (Female vs. Male)
#4 – Describe your overall level of interest in the STEM fields prior to attending the President’s Academy.	4.125 (0.793)	4.067 (0.458)	4.176 (1.015)	0.346
#5 – How did attending the President’s Academy alter your level of interest in the STEM fields?	4.125 (0.660)	3.867 (0.640)	4.353 (0.606)	0.018 (Significant Difference)

(Response Scale for #4: 5 = very high, 4 = high, 3 = average, 2 = low, 1 = very low)

(Response Scale for #5: 5 = significant increase, 4 = increase, 3 = no change, 2 = decrease, 1 = significant decreased)

As previously mentioned, the academy program for session #2 contained a wide variety of activities and several trips. The survey instrument used for session #2 asked students to assess each aspect of the program with respect to its overall value to the program. Students were instructed to assess how each class or activity supported the program objectives, not just their own personal preferences. Table 5 summarizes these results for selected aspects of the program and identifies those aspects of the program that yielded statistical differences, at the 0.05 or 0.10 level of significance, between female and male responses. All top rated activities involved significant hands-on or active learning elements. Only three activities showed significant statistical differences between genders. The nature, rather than content, of the presentations in these activities may have influenced the outcomes.

Table 5: Perceived Overall Value of Selected Program Classes and Activities, Session #2

Selected Class or Activity	All Average Response	Female Average Response	Male Average Response	Ratings (Top 3 in Group)
TTU – Fuel Cell Activity	4.56	4.40	4.71	#1 rated, all students #1 rated, male students #1 rated (tie), female students
Oak Ridge Trip – Tech 2020, Tour, Demo, & Lecture	4.38	4.20	4.53	#2 rated, all students #2 rated, male students #3 rated, female students
TTU – Robot Programming Activity	4.28	4.13	4.41	#3 rated, all students #3 rated, male students #5 rated, female students
Chattanooga Trip – Challenger Center, Mission Simulation Activity	4.16	4.40	3.94	#6 rated, all students #4 rated, male students #1 rated (tie), female students
Chattanooga Trip – Adobe Acrobat as a Communications Standard, Demo	3.44	3.13	3.71	Different at 0.05 level of significance
Chattanooga Trip – U. S. Express, Lecture & Tour	3.59	3.33	3.82	Different at 0.10 level of significance
TTU – Nanotechnology Lecture	4.06	3.87	4.24	Different at 0.10 level of significance

(Response Scale for #4: 5 = very high, 4 = high, 3 = average, 2 = low, 1 = very low)

Lessons Learned

The planning period for the programs described above was extremely short. A post-program review has identified the following lessons learned:

- Professional development workshops for teachers must provide readily usable materials and methods. Teachers should leave the workshop ready to use the materials in their classrooms.
- Lectures, tours, and demonstrations for summer enrichment programs are relatively easy to obtain from education, government, and industry sources. However, financial support is more difficult to obtain.

- Prior planning and coordination are required to ensure a cohesive program. First-year mistakes included unnecessary repetition of introductory material by different speakers and attempting to cover too many topics during a single tour.
- Students selected on the basis of interest alone may not benefit from the program as much as students selected on the basis of both academic criteria and interest. Combining students from a wide range of grades in the same session was also problematic. Different programs are required.
- As expected, activities incorporating hands-on and active learning elements tend to be the most effective from the student perspective. However, these features alone do not guarantee success.
- Both one-day and overnight trips are very effective for expanding the resources available for the program. However, the extensive planning, additional staffing, and extra cost required for overnight trips make them significantly less feasible.

Future Plans

Tennessee Tech is continuing to work with the school systems in Giles, Maury, Warren, and Williamson Counties to assist in their efforts to incorporate the emerging technologies into K-12 curricula. Each county has approached the task in a different way.

- Giles County is focused on building a nanotechnology program, with a laboratory facility, as part of its vocational education program. A new elective course in nanotechnology was offered for the 2005-2006 school year.
- Warren County is integrating emerging technology throughout its high school curricula, with special emphasis on the sciences, mathematics, and English. The students from Warren County who attended session #1 of the President's Academy have been grouped, as much as possible, and assigned to classes taught by teachers who attended the "Preparing for Emerging Technologies" workshops.
- Williamson County is focused on strengthening their offerings in the field of biotechnology, in support of a major biotechnology research, development, and business incubator center that is being constructed in the county.

Tennessee Tech will offer two sessions of the President's Academy for Emerging Technologies in the summer of 2006. A short session will be conducted for students from the original partner counties. A two-week session will be advertised State-wide and students will be competitively selected.