2006-830: EMBEDDED COMPUTER SYSTEMS & PHOTONICS: A PROFESSIONAL DEVELOPMENT COURSE FOR MIDDLE AND HIGH SCHOOL TEACHERS

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Embedded Computer Systems & Photonics: A Professional Development Course for Middle and High School Teachers

Abstract

The STEM (Science, Technology, Engineering, and Mathematics) Fellows Program was a new initiative of the Northeast Network STEM Pipeline Project in 2004-2005, to focus attention on STEM education in middle schools and high schools throughout the Northeast region of Massachusetts. The STEM Fellows Program was funded from the Northeast Network's grant from the Commonwealth of Massachusetts Pipeline Fund which is administered by the Massachusetts Board of Higher Education.

As part of the STEM Fellows Program, a 45 hour professional development course for middle and high school teachers was developed and delivered by engineering faculty from a community college. This paper details that professional development course entitled Embedded Computer Systems and Photonics and reports on the researched results.

Introduction

The STEM (Science, Technology, Engineering, and Mathematics) Fellows Program was a new initiative of the Northeast Network STEM Pipeline Project in 2004-2005, to focus attention on STEM education in middle schools and high schools throughout the Northeast region of Massachusetts. The STEM Fellows Program was funded from the Northeast Network's grant from the Commonwealth of Massachusetts Pipeline Fund which is administered by the Massachusetts Board of Higher Education.

The purpose of the Pipeline Fund is:

- "to increase the number of Massachusetts students who participate in programs that support careers in fields related to mathematics, science, technology, and engineering;
- to increase the number of qualified mathematics, technology, engineering, and science teachers in the Commonwealth; and,
- to improve the mathematics, technology, engineering, and science educational offerings available in public and private schools."

The Northeast Network STEM Pipeline Project is a partnership between the University of Massachusetts Lowell, Northeastern University, Salem State College, Gordon College, Endicott College, Northern Essex Community College, Middlesex Community College, Northshore Community College, eight school districts, three work investment boards, and three industry partners. (See http://www.nepipeline.org/members.htm for the complete list.)

STEM fellows were to be selected in teams of five by their school districts in the Northeast region of Massachusetts and given an opportunity to develop a comprehensive and integrated understanding of STEM issues through a variety of professional development programs. Each team of STEM fellows was then asked to develop a Capstone Plan to improve STEM efforts in their districts.

This paper describes a STEM Fellows professional development course provided between March 3, 2005 and June 9, 2005 by the Engineering Science faculty of Northern Essex Community College in Massachusetts, entitled Embedded Computer Systems and Photonics.

This 45-hour professional development course introduced aspects of the content fields of Applied Mathematics (using algebra, geometry, and trigonometry in Embedded Computer Systems and Fiber Optics), Computer Science and Information Technology (including math for information technology, Boolean Algebra, digital logic, an introduction to embedded microcontrollers, and programming in NQC (Not Quite C), and Science/Technology (robotics using the Mindstorm kits to build programmable robots, engineering design of digital logic circuits, power supplies, and fiber optics). Within this course, the above content areas were shown in relationship to the standards of the Massachusetts Curriculum Frameworks for Mathematics and the Massachusetts Curriculum Frameworks for Science/Technology.

Research was done by a researcher from the University of Massachusetts Lowell to measure the effectiveness of the entire STEM Fellows Program and included qualitative pre-surveys and post-surveys of the STEM Fellows, focus groups with the STEM fellows, and an evaluation of their Capstone Plans. The data gathered which relates directly to the STEM Fellows who participated in this Embedded Computer Systems course was analyzed and included in the paper.

Three professional development courses, funded by the Northeast Network STEM Pipeline Project, were offered in the Northeast region of Massachusetts, one course by Northern Essex Community College (NECC), one by Salem State College, and one by the University of Massachusetts Lowell. The three professional development opportunities were offered to the 34 STEM Fellows between February and June of 2005. Eleven of the STEM Fellows who came from three of the eight school districts chose to participate in the course at NECC entitled Embedded Computer Systems & Photonics. Three out of these eleven STEM Fellows were high school teachers; the remaining eight teachers taught middle school. Professors Michael Pelletier, Paul Chanley, Russ Gouviea, and Wayne Kibbe, all faculty members from the Computer Technology and Engineering Department at Northern Essex Community College, were the instructors.

Professional Development Course Description

The Embedded Computer Systems and Photonics course was a 45 hour professional development institute for STEM Fellows. The class met for 3.5 hours once a week for 13 weeks with course material covering content fields of Applied Mathematics, Computer Science, Information Technology, and Science/Technology. Additionally, the course was put on-line with WebCT as a "web-companion" course which allowed the participants access to the course via the Internet. Prerequisites for the high school and middle school teacher participants were high school algebra and an elementary knowledge of trigonometry.

The first meeting focused on an introduction to the course, a review of course goals, expectations, and the web companion feature of the course. Also, during the first day, the STEM Fellows were introduced to logic puzzles such as “Knights& Knaves” and “Lady or the Tiger.” These puzzles are a fun group problem-solving exercise that can be used in classrooms for different ages and abilities of students.

The next several meetings were dedicated to the Lego Mindstorms robots segment. The class modules/labs were classified as Introduction to Lego Mindstorms robots, Programming, and Advanced Programming. All three modules/labs tapped into the content fields of Computer Science and Science/Technology and were available on WebCT. The objective for the introduction module was pedagogical uses of robots. The building of the robots provided kinesthetic learning, pattern matching, foreground/background discrimination, and sequential ordering. The participants learned the purpose of an operating system and how to load firmware. They also learned programming by using small blocks in the graphical programming language provided with the Lego Mindstorms kits. Finally, algorithms, testing, and the process of adding refinements were introduced. The participants worked in groups of two to create a “robot car” and demonstrate its functionality.

The Programming module/lab added programming concepts to the robot activity. The STEM Fellows had to demonstrate the use of programming techniques for repeating elements and add variables to the program. Also, they had to use timers, pseudo code, and “if statements” for decision making.

The last module/lab for the Lego Mindstorms introduced a “C-like” language (NQC - Not Quite C) for programming the robot. Traditional programming languages and systems were discussed as optional methods for programming. The participants modified their programs by using NQC which served to be a gentle introduction to traditional programming. Loops, decisions, sensor reading, and parallel processing were used.

The course then proceeded to Digital Logic, Digital Systems, and data representation. The objective was for the participants to understand and be able to analyze, build, and troubleshoot basic digital circuits involving TTL logic gates, Boolean algebra, and digital logic design. The module began with an introduction, problem-solving activities, and experiments in basic logic gate functions, including AND, OR, NOT, and NAND. Then, the participants were introduced to Boolean algebra and the process of circuit simplification and combinational logic. All lab work and problem solving was done in groups of two.

After the STEM Fellows showed they had a grasp of basic digital logic circuit, a design problem was proposed to them. They were asked to design and build a circuit to indicate if they should “GO TO THE BEACH.” Input variables used were: A) if you have a ride, B) if you have money; and, C) if it is raining. The output for the circuit should be logic

“1” (GO TO THE BEACH), if it is not raining and if you have money or a ride. The teachers seemed to have fun with this project and viewed it as a positive experience.

Once the design project was completed, data representation in digital systems was taught. This entailed binary and hexadecimal number systems and the conversion between the two number systems. Both individual and group problem solving was performed during this module.

The Digital Logic and Number Systems modules were a transition to the next module on Microcomputers and Microcontrollers. The objective of this unit was for the participants to understand microcomputer hardware and software as well as the interaction between the hardware and software. Two hands-on labs were performed, using the FOXII microcomputer and the 8085 simulator.

Following the Microprocessor/Microcontroller modules, the course moved to PC Hardware and Computer Operating Systems. These modules were delivered via WebCT. Discussion and explanation of various hardware components of a personal computer were covered. Accompanying these discussions was a hands-on lab with disassembly and assembly of a PC. Also covered were web and e-mail basics. Following fundamental personal computer hardware, various operating systems were discussed, including Windows 98, Windows 2000, and Windows XP. File management, virus protection, and backup were also discussed. A hands-on lab exercise on configuring an operating system was performed.

The final course topics were Basic AC Quantities, followed by Light Propagation, Snell’s Law, and the Critical Angle of Reflection. These modules covered some of the content field of Applied Mathematics by using algebra, geometry, and trigonometry to solve technical problems. In addition, the content field of Science/Technology was introduced with the discussions of fiber optics and light propagation. Engineering notation was explained, including the importance of representing very large and very small numbers in a systematic way. Mathematical operations were also performed using this notation and metric prefixes.

The learning objective of the Basic AC Quantities module was for the STEM Fellows to understand the difference between DC and AC electricity. Battery power versus the power provided by the electric company and available at a wall socket was discussed as well as AC to DC conversion. Another objective was for the participants to understand the importance of the math concepts in analog electronics. A detail presentation of the sine wave signal was given. This included amplitude descriptors, such as peak, rms, and average voltage. Additionally, the relationship between frequency and period was covered. Group problem-solving activities were performed in class on the sine wave descriptors. Associated with the discussions and problem solving, a lab demonstration of a basic wind turbine was performed. A blade was attached to an AC motor and wind from a room fan was used to turn the blade and rotate the rotor of the motor, thus creating a generator. The output of the motor was monitored by an oscilloscope. The participants could see, via the scope, the generation of a sinusoidal waveform. As the wind velocity increased so did the amplitude and frequency of the waveform. The science behind the increase of induced voltage was discussed.

Once the STEM Fellows had an understanding of the sine wave and its descriptors, light propagation was introduced. The relationship between speed of light, wavelength, and frequency was covered. Problems were performed in class to ensure that participants understood these fundamental concepts. Finally, light reflection and refraction was covered via Snell's Law. The participants were able to calculate the angle of refraction given the appropriate parameters of material and angle of incidence of the incoming beam of light. The Critical Angle of Reflection was also discussed. This is the basic principle of how light propagates down a fiber optic cable. A hands-on lab demonstration of Snell's Law was performed. By using a HeNe laser and a block of glass, the participants measured the angle of refraction and compared it to the calculated results. The critical angle of reflection was shown and the STEM Fellows observed the light traveling down the glass block.

A part of the funding from the Northeast Network was also used to provide each of the STEM Fellows with their choice of teaching materials to take back to their schools. At the conclusion of the course, each of the eleven teachers chose a Mindstorms kit. During the last meeting of the course, each STEM Fellow gave a presentation of a content module each had developed and would use in their classroom. Their modules were based on something they had experienced in the Embedded Computer Systems & Photonics course.

In addition, to illustrate the diverse paths to an engineering career, four engineering professors from the CTE Department at NECC presented their personal stories of how they became engineers. Professor Michael Pelletier went directly from the college prep track in high school to Villanova University for a BEE, followed by an MSEE from Northeastern University. Professor Paul Chanley went directly from the college prep track in high school to Northeastern University for a BS in EE and then to UMass Lowell for an MS in Electrical Engineering. Professor Chanley also worked for twelve years in industry as an electrical engineer. Professor Wayne Kibbe received an A.S. degree from Springfield Technical C. C., worked for several years as a technician, and then went to Arizona State University for a B.S. in Electrical Engineering. Professor Lori Heymans graduated from Greater Lawrence Technical High School in Massachusetts (an important feeder school for NECC) and then graduated from UMass Lowell with a BS in Electrical Engineering. Professor Heymans is currently completing her Master's degree in Applied Mathematics.

A highlight of the course was when the group of eleven STEM Fellows was able to attend a final presentation of senior projects in Embedded Computer Systems given by the computer engineering and computer science students at Merrimack College. After the engineering students' presentations, Professor Vance Poteat of Merrimack spent another hour with the STEM Fellows talking about his personal career path (which included a community college) and the importance of community college graduates to engineering and technology.

Graduate Credit

Ten of the eleven STEM Fellows enrolled in this course opted to take the course for graduate credit through Endicott College in Beverly, Massachusetts. The ten teachers enrolled in a 3-credit course (45 hours) through Endicott's Van Loan School of Graduate and Professional Studies. The NECC professors also served as the course instructors for Endicott College.

Grading system:

	Percentage
Projects, labs, and other work assigned by Professor Chanley	22.5%
Projects, labs, and other work assigned by Professor Gouveia	22.5%
Projects, labs, and other work assigned by Professor Kibbe	22.5%
Projects, labs, and other work assigned by Professor Pelletier	22.5%
Final Presentation of Project by Participant	10.0%
Total	100%

Capstone Showcase

In September of 2005, the Northeast Network STEM Fellows Capstone Showcase was held to provide an opportunity for all of the STEM Fellows Teams to present the plans they had developed to promote greater student interest in STEM careers as well as to advance STEM teaching and learning at the local level. The final plans developed by the 11 STEM Fellows who participated in the Embedded Computer Systems & Photonics reflected the positive influence that this professional development course had on them and how they would implement their new knowledge into their district.

Demographics of Participating STEM Fellows

The eleven STEM Fellows who participated in the professional development course at NECC represented 3 different school districts. Four Fellows were from a suburban school system in Massachusetts; six Fellows taught at in an urban school system in Massachusetts with a significant minority population; and, one participant was from a small city in Massachusetts without a significant minority population.

There were two males and nine females participating in this course. Three (all females) of the group reported that they had worked in a STEM career outside of teaching. One woman had worked as a mechanical engineer for 5 years; another had worked as a computer programmer for 1 ½ years; and a third teacher had worked as a system engineer for 11 years. Ten of the 11 participants hold Master's degrees and have reported themselves as being licensed to teach in their primary STEM subject; the 11th is a first year teacher not yet eligible for license and is currently working towards a Master's degree.

Number of participants	Time teaching at current School
1	11-15 years
5	6-10 years
4	3-5 years
1	1 year

Number of participants	Total Time teaching throughout career
3	15^{+} years
2	11-15 years
5	6-10 years
1	1

Subjects taught by STEM Fellows (Most teachers reported teaching more than one STEM subject):

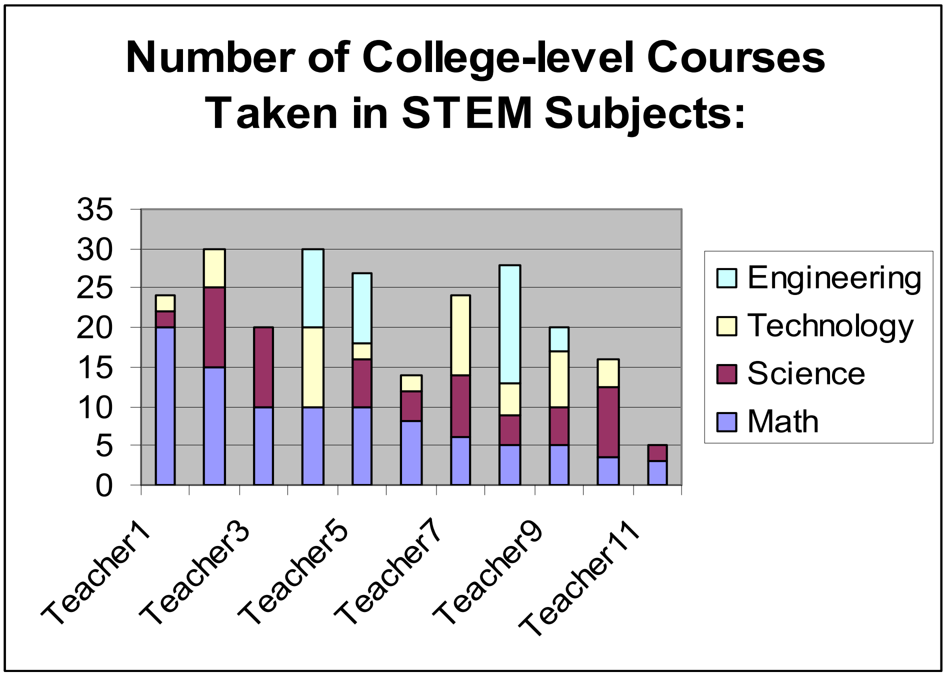
Math	General Science	Physics	Physical Science	Tech. Education	Engineering
11	4	2	2	4	0

Grade levels taught

Grade level(s)	5^{th}	6^{th}	6,7,8	7,8	8^{th}	9,10	9,10,11	9,10,11,12
# of teachers	1	2	1	1	3	1	1	1

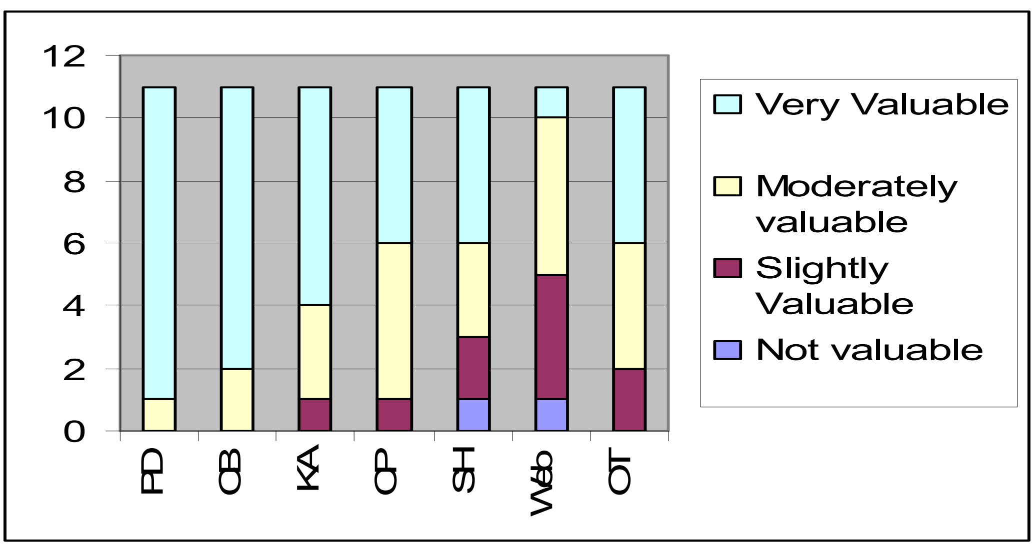
The Number of College-Level STEM Courses Taken by Fellows

The following chart indicates the number of college-level courses taken by each STEM Fellow in math, science, technology, and engineering. Seven out of the eleven participants had never taken an engineering course. However, nine out of the eleven had taken some technology courses.



Post Survey Results--What was the Most Valuable Activity?

The Embedded Computer Systems and Photonics professional development course at Northern Essex Community College was judged to be the most valuable of the seven activities in which the 11 STEM Fellows had participated. It even topped Career Briefings in their estimation of value. To the question **"How valuable did you find each of the following STEM Fellowship program activities?"** the 11 participants answered as follows:



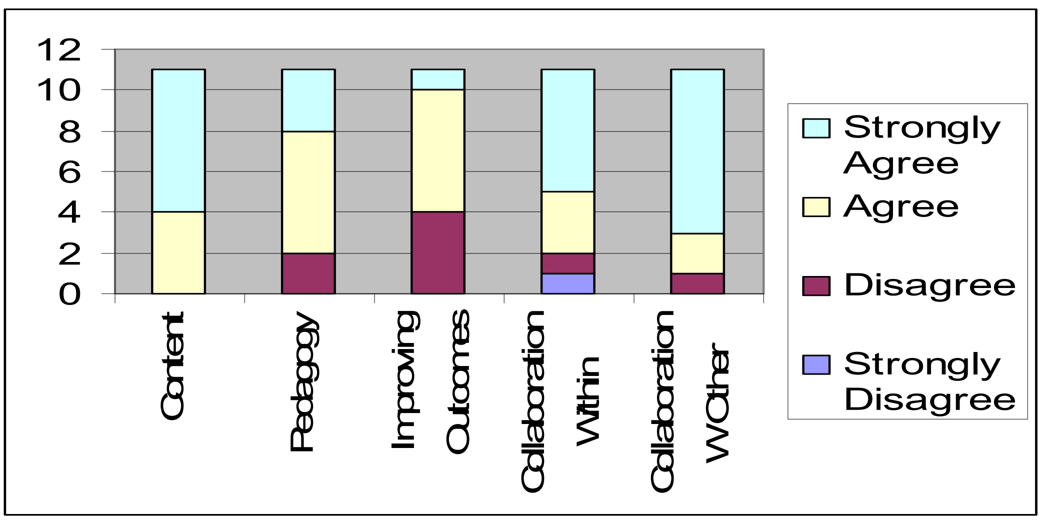
Legend

PD	**The Professional Development Course at NECC**
CB	**Career Briefings presented at the STEM Fellows meetings**
KA	**Knowledge acquired about STEM-related issues within the fellow's district during preparation of Capstone Plan**
CP	**Collaboration with district team members during preparation of Capstone Plan**
SH	**Collaboration with district team members during preparation for final day's showcase**
Web	**The Northeast STEM Pipeline website**
OT	**Watching other district teams present their Capstone Plans at Showcase**

Post Survey Results--What the Professional Development Opportunity Provided

The participants judged the Embedded Computer Systems & Photonics course to be most valuable at providing them with useful content knowledge that could be applied in the classroom and next most valuable at providing opportunities for the Fellows to collaborate with teachers from other districts.

To the question, **"The professional development opportunities that I was exposed to through the STEM Fellows program provided me with …,"** the responses were as follows:



Legend

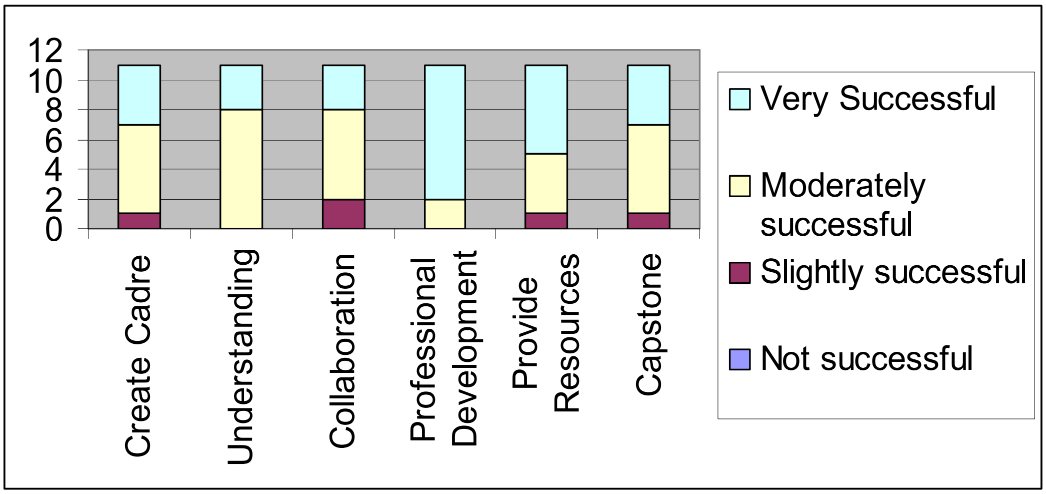
Content	**useful content knowledge that I can use in my classroom**
Pedagogy	**useful pedagogical knowledge that I can use in my classroom**
Improving Outcomes	**strategies for improving student outcomes (for example, test scores or enrollment rates.)**
Collaboration Within	**opportunities to collaborate with STEM Fellow teachers in my district.**

Collaboration W Other	**opportunities to collaborate with teachers from other districts during the STEM Fellows project**

Post Survey Results--Outcomes Produced

When asked to rate how successful the STEM Fellows project was at producing various outcomes, the eleven STEM Fellows who participated in the Embedded Computer Systems & Photonics course rated the project most successful at providing professional development opportunities whose effects carried over into their classroom activities.

To the question, **"How successful do you feel that the Northeast STEM Pipeline project was for each of the following:"** the 11 STEM Fellows responded as follows:



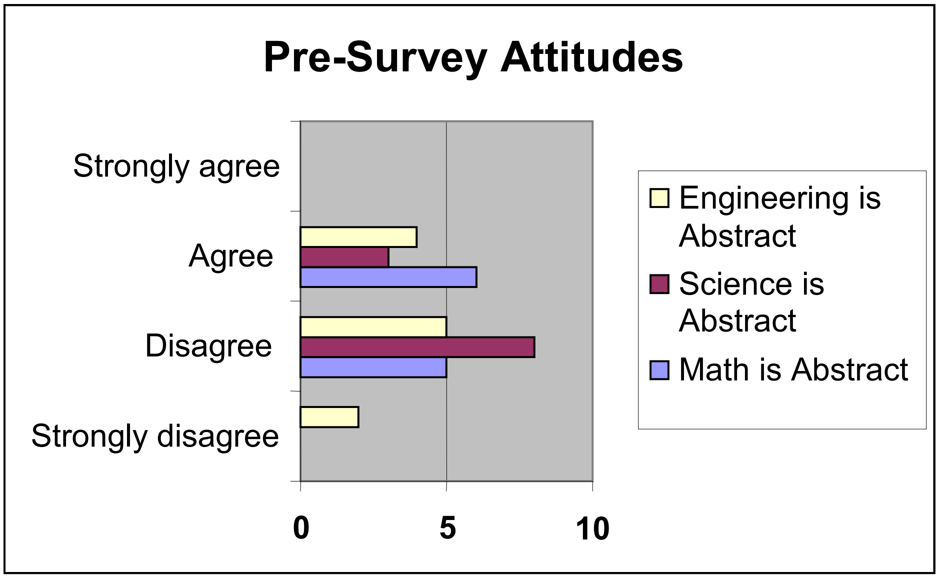
Legend

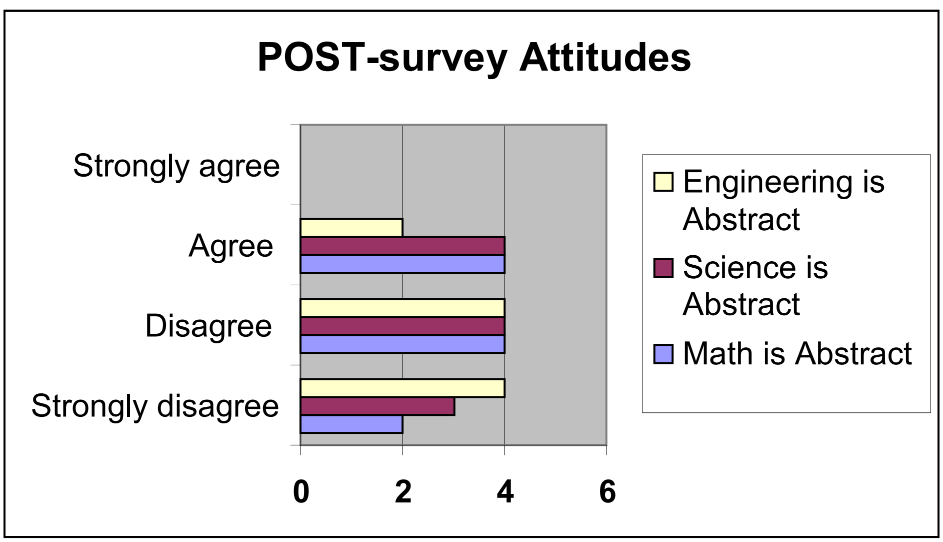
Cadre	**Creating a cadre of STEM teacher leaders in your district?**
Understanding	**Increasing the level of understanding of STEM-related issues in your district?**
Collaboration	**Fostering collaboration among STEM teachers in your district?**
Professional Development	**Providing you with professional development opportunities whose effects carry over into your classroom practices?**
Resources	**Providing you with local and regional resources outside of your school and district that can be used in the future?**
Capstone	**Helping you to create a sustainable Capstone Plan for your district?**

Post Survey Results--Attitude Shifts Among STEM Fellows

In both the Pre-survey and the Post-survey, the STEM Fellows were asked the question, **"To what extent do you agree with each of the following statements? Mathematics,**

Science and Engineering are primarily an abstract discipline." After going through the STEM Fellows Program experience, the participants shifted their views and saw STEM subjects as less abstract disciplines. Perhaps due to the hands-on lab experiences of the Embedded Computer Systems & Photonics course, the most profound shift in attitude was in viewing engineering as much less abstract in the post-survey.



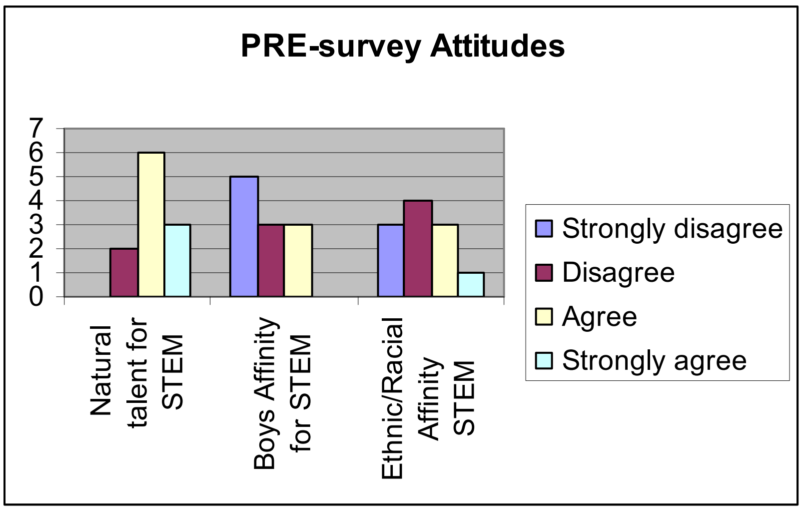


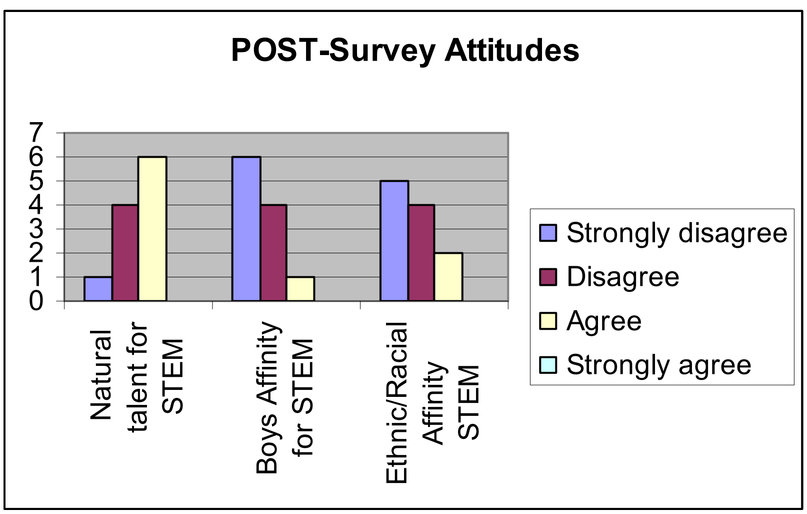
Post Survey Results--Other Attitude Shifts among STEM Fellows

In both the Pre-survey and the Post-survey, the STEM Fellows were asked the question, **"To what extent do you agree with each of the following statements?"** **(1)** "Some students have a natural talent for STEM subject areas and others do not." **(2)** "Boys have a greater affinity for STEM subject areas than girls." **(3)** "Some ethnic/racial groups have a greater affinity for STEM subjects than others." (Data is shown below in chart form.)

Prior to the participant's experience, some of the STEM Fellows believed that some students had a natural talent for STEM subject areas. However, after taking the course, their opinion shifted towards disagreeing with the natural talent statement. Also, there was a slight shift towards a stronger disagreement stance when regarding both gender and ethnic/racial groups as having a greater affinity for STEM subjects.

The pre/post survey also indicated that the STEM Fellows believed that family influences and the lack of understanding of the STEM career opportunities are extremely important factors influencing student's choices about pursuing STEM careers. Their attitudes did not shift after their program experience. (Data not included.)





Conclusions:

The pre and post surveys show that the Embedded Computer Systems & Photonics professional development course made an important contribution to achieving the three goals of the Pipeline Fund:

- "To increase the number of Massachusetts students who participate in programs that support careers in fields related to mathematics, science, technology, and engineering;
- To increase the number of qualified mathematics, technology, engineering, and science teachers in the Commonwealth; and,
- To improve the mathematics, technology, engineering, and science educational offerings available in public and private schools."

1. By being exposed to engineering and engineering technology and having been helped to positively shift their attitudes toward math, science, engineering, and technology, these STEM teachers will be better prepared to guide their students into choosing STEM careers.

2. By experiencing college-level content and hands-on lab activities in embedded computer systems, these STEM teachers will be better able to improve the mathematics, technology, engineering, and science offerings available in their schools.

3. The STEM Fellows are meant to function as mentors and change agents in their school districts. As such, they are now more knowledgeable about computer-related STEM subjects and can help to increase the number of qualified STEM teachers from among their colleagues.

4. For 7 of the 11 STEM Fellows participating in this course, this was their first exposure to a college-level course that included engineering. For 2 of those 7, this was also their first exposure to a college-level course that included technology.

5. As a qualitative measure of how well-received was this course, at the Capstone Showcase in September of 2005, the 11 participants requested that NECC seek funding to offer another professional development course in the spring of 2006 so that they could increase their content knowledge of engineering and technology. In the spring of 2006, Boston's Museum of Science provided funding to allow NECC to offer to middle and high school teachers a professional development course emphasizing mathematical topics as used in engineering and technology.

Comments made in February 2006 by two participants in the Embedded Computer Systems course:

"I am currently 'mentoring' 4 students - 2 girls and 2 boys on the Lego Mindstorms kits. These are bright students who may never have thought of engineering and are now considering it for a career. I also use some of the logic puzzles - knights and knaves - as class 'fillers' when I have 5 extra minutes here and there. I was also happy to show a 7th grade teacher what we learned about the binary system - she was covering a unit with her advanced students!"

"The most salient point I brought back to my classroom was the need for my students to become thinking human beings. In the quest to have them succeed on a standardized test, we had lost the notion of creativity. We 'taught' to the test. Once I took your class, however, that changed. I've used and continue to use logic examples (Knights, Knaves, etc.) in my classes to get the students to 'think outside the box'. I ask a lot more probing, open-ended questions, like 'What would happen if.......' I've also used the Lego Mindstorms kit. For the gifted students, it is a wonderful way for them to work on their own, discover, and work at their own paces....creatively. For others, it opens their minds to different ways of doing things. I've even used it as a motivator for students who, otherwise, might not want to master my lessons. If they finish and master the skills they need to, they get to build. In addition, using the kit addresses a branch of the science frameworks that would have otherwise, gone unaddressed. By building, the students get to be 'engineers' and use the engineering design process. I have carried this through to other aspects of my curriculum, such as building bridges and designing roller coasters. Your course opened my eyes to a different way of teaching."

Detailed Syllabus with Objectives:

3/3/05 Knights & Knaves

Objective : Using Logic puzzles in a classroom setting
Project : group problem solving

1) Introduction logic puzzles : Knights always tell the truth; Knaves always lie.
2) Solving techniques. Adding Normals (Sometimes lie, sometimes tell the truth)
3) Group solving & practice problems.
4) A different kind of puzzle – Lady or the Tiger
5) Usage in a classroom for different age/ability groups

3/10/05 Introduction to Lego Mindstorms Robots

Objective: Pedagogical uses of robots
Project: Lab 1 (on the web site)

1) Building the robot: Kinesthetic learning, pattern matching, foreground/background discrimination, Sequential ordering
2) Loading the firmware -- what an Operating system does.
3) Programming using the small blocks in the graphical programming language
4) Algorithms, An iterative approach to programming, Testing
5) Adding refinements, working with random numbers

3/24/05 Programming Concepts

Objective: Adding programming concepts
Project: Lab 2 (on the web site)

1) Using functions for repeating elements
2) Adding variables to the program
3) Using timers
4) Making decisions (if statements)
5) Using pseudocode

3/31/05 Moving to a traditional programming language

Objective introduce a C-like language for programming with an IDE
Project: Lab 3 (on the web site)

1) Optional programming languages/systems
2) Introduction to NQC (Not Quite C) for programming Mindstorms
3) Using the Bricxcc IDE for programming
4) Modifying programs as a gentle introduction to traditional programming
5) Using loops, decisions, sensor readings and parallel processing

4/7/05 Digital Logic

Objectives: Understand and be able to analyze, build, and troubleshoot digital circuits involving:

1. Logic gates
2. Boolean Algebra
3. Karnaugh Mapping
4. Digital Logic Design

Project: Design a simple logic circuit and build with TTL logic chips.

Fuzzy Logic
Objective : Understand how fuzzy logic works, differences between Boolean logic and fuzzy logic
Project : Group problem Solving

1) Introduction to fuzzy logic
2) Manipulating fuzzy objects
3) Understanding the concept of certainty
4) Using fuzzy logic to control a system

4/14/05 More Digital Logic

Objectives: Understand and be able to analyze, build, and troubleshoot digital circuits involving:

1. Logic gates
2. Boolean Algebra
3. Karnaugh Mapping
4. Digital Logic Design

Project: Design a simple logic circuit and build with a Multiplexer.

4/28/05 Data Representation in Digital Systems

Objectives: Understand
1) Binary number system
2) Hexadecimal number system

Project: Conversions between Number Systems

Microcomputers & Microcontrollers
Objectives: Understand
1) Microcomputer Hardware
2) Microcomputer Software
3) The Interaction of hardware and software
4) Using binary and hexadecimal in microcomputer systems

Project: Making memory maps from schematics
Hands-on labs: using the FOX II microcomputer

5/5/05 Microcomputers & Microprocessor Simulators

Objective: Understand Microprocessor simulators
Hands-on labs: using the 8085 Simulator

5/12/05 PC Hardware

Online: Review Chapter 1: Computer, Web and email Basics
Review Chapter 2: Computer Hardware

Lecture: Discussion and explanation of various hardware components of a Personal Computer.

Lab: Disassembly and Assembly of a personal computer. Hands-on lab involving hardware components of a personal computer.

5/19/05 Computer Operating Systems:

Online: Review Chapter 3: Computer Software and Operating Systems
Review Chapter 4: File Management, Virus Protection, and Backup

Lecture: Discussion of various operating systems including Windows 98, Windows 2000 and Windows XP.

Lab: Hands-on exercises configuring operating systems.

5/26/05 Basic AC Quantities

Objectives: Understand

1) how mathematics is used in a computer system's analog electronics
2) how AC is converted to DC by the power supply of the computer system.

Background information:

1) difference between ac and dc electricity (Bat vs. wall outlet)
2) Introduce information regarding ac sine wave signal. Sine wave descriptors
3) V_{peak}, $V_{peak\ to\ peak}$, V_{rms}, V_{avg}
4) Relationship between frequency and period ($f = 1/T$).
5) Manipulation of engineering/scientific notation.

6/2/05 Light Propagation / Snell's Law

Objectives: Understand

1) the relationship between speed of light, wavelength and frequency
2) Snell's Law, light index of reflection, refraction and incidence

Background information on light and electromagnetism properties:

1) The relationship between speed of light, wavelength and frequency ($c = \lambda f$)
2) Snell's Law, light index of reflection, refraction and incidence.
3) ($\eta 1 \mathrm{Sin}\theta 1 = \eta 2 \mathrm{Sin}\theta 2$)

Lab work: Demonstrate Snell's law and Critical angle with laser pointer and a block of glass/plastic.

6/9/05 Final presentation of participant projects: participants demonstrated a unit based on some topic learned in the course that they will take back to the classroom. As seen by the results of the surveys, each team felt that one or more of the course topics was useful and applicable to them. At the final meeting, each team delivered a PowerPoint presentation showing what they learned from the course, what topics they would cover, and how they would implement those topics in the classroom. In addition, the teams also took the opportunity to show how the course increased their comfort level with the technical topics and how it provided new ideas and techniques on how to present other topics as well.