North Penn High School Engineering Academy
Nanotechnology Education And Research
North Penn High School
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www.TheFutureIsNear.org

Program Information – The Future is N.E.A.R. / Michael A. Boyer

January 16, 2008

N.E.A.R. Program Information (Nanotechnology Education And Research):

Program inception date	2005-2006 School year
Current number of students in nanotechnology research	18 (1 class)
Student time during the school day	45 minutes/day - Full Year

Grant / Funding Awards:

November 2007	North Penn Education Foundation	$597.00
March 2006	Toyota	$10,000.00
March 2006	North Penn Education Foundation	$650.00
September 2005	ING Financial	$2000.00
July 2005	Dominion	$4500.00
June 2005	Toshiba	$4900.00

What is the Future is N.E.A.R.? (www.thefutureisnear.org)

The Future is N.E.A.R. program (Nanotechnology Education And Research) is the only known program of its kind designed to teach engineering and nanotechnology research through a polymer nanofiber production process known as electrospinning to high school students.

The N.E.A.R. program offers the students of North Penn High School's Engineering Academy a unique opportunity to gain 21st century skills that will help prepare them to become successful and highly marketable leaders in our global technological society. The program introduces the fundamentals of nanotechnology, engineering research, and higher level thinking and application of knowledge to high school students while cultivating their interest in engineering, problem solving and life-long learning.

The Main Goals of The Future is N.E.A.R. Program are to:

1.) Inform and educate students about nanotechnology, submicron measurement and the present and future applications of nanotechnology.
2.) Introduce engineering research as a method of increasing intrinsic motivation, self directed learning and the acceptance of failure as a positive "side effect" of research and learning.
3.) Identify nanotechnology and its related mathematical and scientific components as a necessary program for cultivating student learning and preparing them to be competitive, productive members of a 21st century global society.
4.) Improve science, technology, engineering and mathematical (STEM) knowledge and skills utilizing a collaborative, real-world research environment to help achieve the goals of the Technology for all Americans initiative.
5.) Incorporate "Quadrant D" learning and assessment as identified by the International Center for Leadership in Education and High Yield Strategies as identified by Robert Marzano.
6.) Invite local businesses and educational institutions to participate as partners in shaping future generations of the local/global workforce.

N.E.A.R. Program Future Goals

As the N.E.A.R. program grows and develops, I would like to see the program offered in other schools. Utilizing the Internet as the main mode of communication, students would be able to share research, experimental processes and procedures, images, blogs, video and audio podcasts, large format presentations, joint research projects, collaborative projects between local businesses and universities and research of new products and applications within the engineering and nanorealm.

What is the Engineering Academy at North Penn High School?

The engineering academy is a specialized sequence of courses within the Technology Education Department at North Penn High School, located in Lansdale, PA. The academy is designed around a national pre-engineering program called Project Lead the Way which represents a course sequence that addresses the educational needs of students planning on a post high school educational program in a two or four year college leading to a career in engineering or engineering technology. The program offers students an opportunity to explore potential occupational paths and to prepare for the college experience. The students involved in the engineering academy are engineering bound sophomores, juniors and seniors.

Current Partnership

Drexel University is an integral component of the N.E.A.R. program. Drexel offers the students opportunities to work directly with Dee Breger, Director of Microscopy in the Drexel Nanotechnology Institute (DRI), to utilize their Scanning Electron Microscopes. The students, under Dee's direction, take control of the scanning electron microscopes to capture images of highly magnified views of their fibers (20,000x and higher) to identify surface characteristics and obtain diameter measurements.

Future Partnerships

Currently, the engineering academy is seeking partnerships with local businesses and other universities to act as a liaison between the world of education and the engineering / business world. For the engineering academy in general, we are looking for members from local business and engineering firms to help us establish a partnership team. This team, formed with local businesses, universities and teachers within the engineering academy, would act as a place for us to share ideas, gain perspective from local industry about what and how we should be preparing our students and to act as a resource of information.

For the nanotechnology course, I am also seeking assistance with research methodologies, polymer science and chemistry applications to the nanotechnology and polymers arena, active research collaborations between the high school and business, sources of funding and visitations from industry professionals and trips to local businesses to see engineering and research in action.

Background Information – Nanotechnology in the Classroom

Please see my curriculum vitae for further detailed information about my experiences.

From 2003 - 2006, I performed nanotechnology research at Drexel University in Philadelphia, PA. The research I was involved with was a result of being selected to participate in their RET, (Research Experience for Teachers) National Science Foundation funded program. During that time, I worked in the Fibrous Materials Research Laboratory working with Dr. Frank Ko and his graduate and doctoral students. My primary focus was in the nanofiber development process (both conductive and nonconductive). What an amazing group of individuals.

During my first summer in the RET program at Drexel, I was introduced to nanotechnology and the electrospinning process. I immediately fell in love with the research process, the interaction with people who are masters in their field, and Drexel University. It was from then on that I wished I could lead dual lives; one life in education and one life in research! From this desire, I quickly began to devise a way to introduce the research experience and in particular, nanotechnology to my students. The largest obstacles to overcome for me were finding the time to develop the activities, when I would teach the new course and acquiring the necessary funding to begin a nanotechnology program.

The second summer at Drexel was spent with the RET-Nano group. It was during this experience that I obtained a taste of actual research. I worked on the development of an electroactive polymer actuator - (A plastic that could conduct electricity and move like a hinge when voltage was applied.) I electrospun pedt/pss [polyethylenedioxythiophene/poly (styrenesulfunate)], a conductive polymer solution onto Nafion© film (A thin flexible plastic developed by DuPont). While I was able to electrospin nanofibers that were conductive (amazing – to get plastic to conduct electricity); the Nafion was not actuating as hoped and before long, the five weeks (there is never enough time) were concluding and there was no time left to continue the research.

By this point, I was determined to begin research with my students. I quickly began developing a nanotechnology research activity for the students in our Engineering Academy. I gave it a name; The Future is N.E.A.R. (**N**anotechnology **E**ducation **A**nd **R**esearch). I then wrote for five grants during the 2004 school year and won three. Toshiba awarded the program $4,930, Dominion awarded the program $4,500, and ING financial awarded a $2,000 grant. Now, all I needed were the facilities to develop the lessons and the research activities. I applied again to the Drexel RET program and was offered a third opportunity as an independent study student. This time, I utilized the research time to develop my curriculum and student activities. This summer proved to be the integral component of my three year experience at Drexel for the N.E.A.R. program.

During the 2005-06 school year, I was awarded a $600.00 North Penn Education Foundation grant for a deionized water producer and a $10,000 grant from Toyota and the National Science Teacher Association. This grant was written to obtain materials to develop two vertical electrospinning stations and a metered syringe pump so that we can do more accurate studies of the electrospinning process.

My students and I are currently in the middle of the program this year. Up to this point, my students have a gained a an understanding of nanotechnology from a size and scale perspective, background in polymer safety with MSDS research, they have prepared their polymer solutions, performed informal electrospinning experiments to identify some of the independent variables and are now creating their team websites to share their research. The students are working in research teams (3 students per team) that focus on changing the variables within the electrospinning process such as the *polymeric properties* (weight percentage, molecular weight), *field strength* (voltage [0 to 30,000 Volts]) *distance* (between the charged solution and the collection plate), *station apparatus* (polymer syringe angle, collection plate material) and many other variables. The students are now becoming familiar with many of the parameters in their informal experiments and have begun designing their own experiments to see how these variables affect the results. (Please see the pictures on page 4)

When the students complete much of their electrospinning experiments this year, they will begin to formulate conclusions to their research by working with Dee Breger, Director of Microscopy in the Drexel Nanotechnology Institute (DRI) of the Department of Materials Science and Engineering at Drexel University in Philadelphia, to utilize their Scanning Electron Microscopes. The students, under the direction of Dee Breger, will be taking control of the scanning electron microscopes to take highly magnified views of their fibers (20,000x and higher) to identify surface characteristics and diameter measurements of their electrospun nanofibers. (Please see the SEM images on page 4)

The students' final goal will then be to formulate their research to be included into a formal presentation. Their websites as well as scientific research papers will hopefully be submitted to be published internationally. Ultimately, the students will be creating a library of research documents that can serve as a base line for future students to model. Data analysis, synthesis and compilation of their data will conclude much of their research, but some might find this to be just the beginning as much of their conclusions will lead them to more questions than answers.

The students have already expressed an interest in furthering their research to the conductive polymer arena, a study of the whipping action of the fibers during the electrospinning process utilizing high speed photography (1,000 to 5,000 frames per second), the effects of changing the solvent to contain specific impurities and much more. The students are gaining a passion for the research process. They are writing all of the ideas that they want to research in their engineering journals and come to class everyday with questions and ideas for further research.

It is amazing to see the students take command of their own learning and design research experiments to answer questions that they have. Soon, these students will have the skills, knowledge and intrinsic motivation to become global leaders in engineering and nanotechnology: the technological industrial revolution of the 21st century.

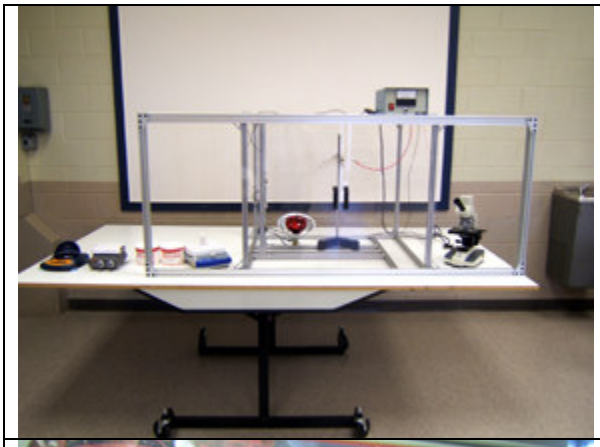
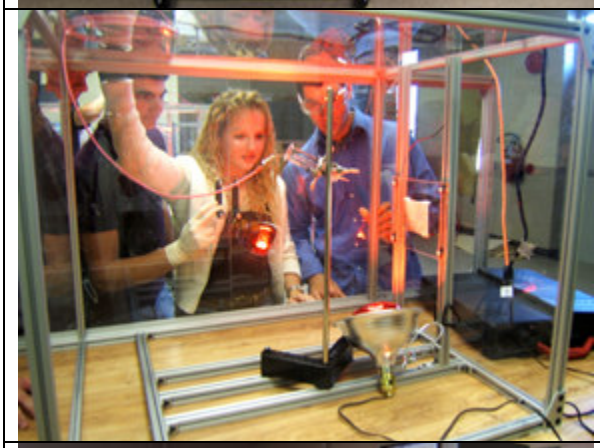
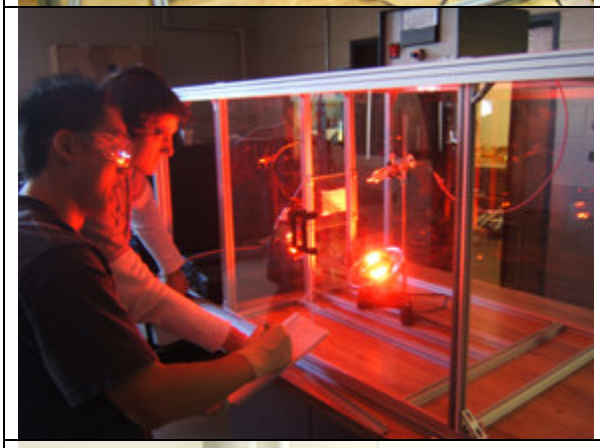
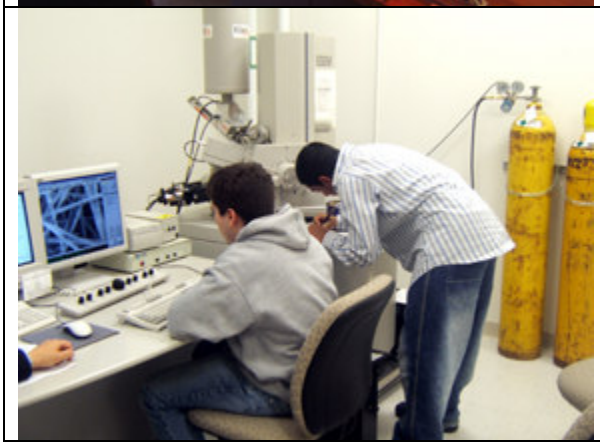
Future Grants and Opportunities

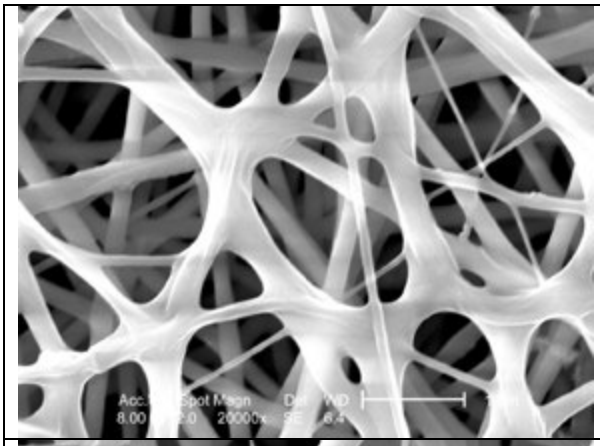
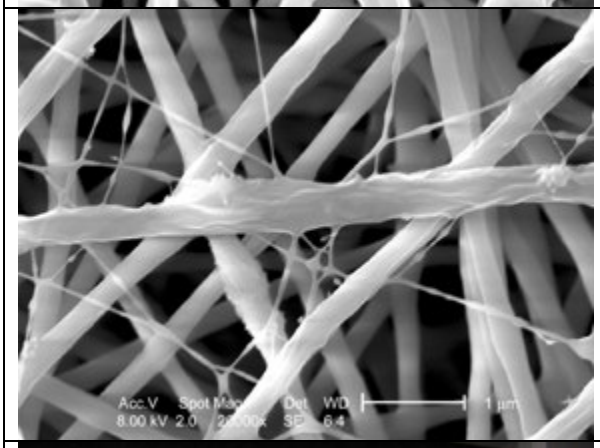
In December, Evan Slow, a representative from Angstrom Scientific,came to North Penn High School's engineering academy. He set up and demonstrated the Hitachi TM-1000, a desktop scanning electron microscope. This microscope is easy to use, robust and has a relatively low operating cost. I am currently looking for grant opportunities or joint funding ventures to help to acquire one of these machines. This equipment will allow the students within the engineering academy to do fundamental analysis of the nanofibers and other experiments in-house. We will also be able to collaborate with other departments to create a truly interdisciplinary approach to teaching and learning.

I am also looking for ways to collaborate with math and science teachers to create a cross-curricular nanotechnology course.

Images of Student Research

Below are some images of students performing their research in the laboratory:

	Electrospinning Station Electrospinning is a process by which fibers are drawn out from a viscous polymer solution or melt by applying an electric field (5,000 to 30,000 volts) to a droplet of the solution (most often at a metallic needle tip). The electric field draws this droplet into a structure called a Taylor cone. If the viscosity and surface tension of the solution are appropriately tuned, a stable jet is formed. A bending instability results in a whipping process which stretches and elongates this fiber until it has a diameter of micrometers or nanometers. The fiber is then deposited on a grounded collector.
	Students Electrospinning
	Students Electrospinning
	Students Utilizing the Scanning Electron Microscope at Drexel University

	Scanning Electron Microscope image of student created nanofibers (average diameter less than 200 nanometers)
	Scanning Electron Microscope image of student created nanofibers (average diameter less than 200 nanometers)
	Final Presentation to over 175 teachers, administrators, engineering faculty from Drexel and Penn, parents, family and friends.

Reference Information

The Future is NEAR
General program information
http://www.TheFutureIsNEAR.org

Engineering Academy Website:
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http://www.northpennengineering.org