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NUE: NanoTechnology Education and Experiences in Maine (Nano-TEEM)

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Principal Investigator: Smith, Rosemary L.
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Organization: University of Maine
Submitted By:
Smith, Rosemary - Principal Investigator
Title:
NUE: NanoTechnology Education and Experiences in Maine (Nano-TEEM)

Project Participants

Senior Personnel

Name: Smith, Rosemary
Worked for more than 160 Hours: Yes
Contribution to Project:
Dr. Smith is the principle investigator for this project and the primary developer of the Intro to Nanoscale Science and Engineering course.

Name: Collins, Scott
Worked for more than 160 Hours: Yes
Contribution to Project:
Dr. Collins is a co-principle investigator for this project. He has primary responsibility for development of a tutorial on Nanoscale Science for incorporation into the first-year college Chemistry course. He is assisting in the development of lab modules for 1st and 2nd year engineering students.

Name: Bernhardt, George
Worked for more than 160 Hours: Yes
Contribution to Project:
Dr. Bernhardt is a senior scientist who is assisting in the development of course content, particularly the laboratory experiences. He has led discussions in several laboratory experiences so far this semester. He has primary responsibility for making sure that the lab equipment is functioning and everything is prepared for the weekly lab experiences.

Post-doc

Graduate Student

Name: Sterling, Sarah
Worked for more than 160 Hours: No
Contribution to Project:
Ms. Sterling assisted Dr. Neivandt in the development of the lab module on surface modifications and she took the lead in running the laboratory experience.

Name: Garay, Timothy
Worked for more than 160 Hours: Yes
Contribution to Project:
Tim is developing both course materials, e.g. quizes, and assessment methods and materials, as a course Teaching Assistant. He is supported both by the NUE project and by a Math and Science Teaching program as a TA for the Physics Department at UMaine.

Name: Spinney, Patrick
Worked for more than 160 Hours: Yes
Contribution to Project:
Patrick assisted in lab preparation and instruction for three modules, and participated in outreach activities with visiting middle school students.

Name: Duy, Janice

Worked for more than 160 Hours: Yes

Contribution to Project:

Janice assisted in the gold nanoparticle synthesis and the fluorescence microscopy laboratory module preparation and provided instruction during the laboratory periods. She also developed the procedures for a lab module on stamping of biotin and biotin-avidin binding.

Undergraduate Student

Name: Cota, Ryan

Worked for more than 160 Hours: Yes

Contribution to Project:

Mr. Cota is a 2.5 year undergraduate student in Electrical & Computer Engineering, who has been a participant in Dr. Smith's research group since he was in high school. Mr. Cota is assisting in the development of laboratory experiences for the course and as a technical resource during the laboratory sessions. He has taken the lead in demonstrating and instructing students in at least one laboratory experience so far this semester (Fall 2008).

Name: Demers, Christopher

Worked for more than 160 Hours: Yes

Contribution to Project:

Mr. Demers is developing the course website, and assisting in the lab excercise development. He is likely to be involved in course laboratory execution in spring 2010.

Technician, Programmer

Name: Doore, Brian

Worked for more than 160 Hours: Yes

Contribution to Project:

Brian Doore is a research associate in the College of Education and Human Development at UMaine. He is assisting Prof. R.L. Smith, PI, to develop course assessment materials, specifically an on-line questionaire that students completed each week of the course. NUE grant funds were used to pay approx. 5 weeks of Brian's salary in 2010. Brian completed an assessment for the course held in Spring 2010 and provided Prof. Smith with a report.

Other Participant

Name: Millard, Paul

Worked for more than 160 Hours: No

Contribution to Project:

Dr. Millard developed a tutorial on applications of biomolecules in micro and nano devices, and a lab module re. biomoleculepatterning on surfaces.

Name: Neivandt, David

Worked for more than 160 Hours: No

Contribution to Project:

Dr. Neivandt developed a tutorial on amphiphilic molecules and their applications to nanodevices and self-assembly and another on nanolignin for nanofiber applications. He also helped to develop a lab module on ice-templating of nanolignin to manufacture nanotubes.

Name: Kotecki, David

Worked for more than 160 Hours: No

Contribution to Project:

Dr. Kotecki delivered 2 lectures (tutorials) on Nanoscale Electronics to the class, both in the Spring and Fall 2010 offerings.

Name: Shahinpoor, Mohsen

Worked for more than 160 Hours: No

Contribution to Project:

Dr. Shahinpoor delivered 2 lectures (tutorials) on Smart Materials and Artificial Muscles to the class, both in the Spring and Fall 2010 offerings. He also prepared a hands-on laboratory module which included actuation of artificial muscle material.

Name: Gardner, Douglas

Worked for more than 160 Hours: No

Contribution to Project:

Dr. Gardner delivered 1 lecture (tutorial) on Structural Nanocomposites to the class, both in Spring and Fall 2010 offerings.

Name: Emanetoglu, Nuri

Worked for more than 160 Hours: No

Contribution to Project:

Dr. Emanetoglu delivered 2 lectures (tutorials) on Nanophotonics to the class, both in the Spring and Fall 2010 offerings. He also demonstrated optical spectroscopy of sunlight and LEDs during the solar energy lab experience.

Name: Mason, Michael

Worked for more than 160 Hours: No

Contribution to Project:

Dr. Mason delivered 2 lectures (tutorials) on optical properties of nanoparticles to the class, both in the Spring and Fall 2010 offerings.

Name: Unertl, William

Worked for more than 160 Hours: No

Contribution to Project:

Dr. Unertl delivered 2 lectures (tutorials) on Scanning Probe Microscopy to the class, both in the Spring and Fall 2010 offerings.

Name: Lad, Robert

Worked for more than 160 Hours: No

Contribution to Project:

Dr. Lad delivered 2 lectures (tutorials) on Thin Films to the class, both in the Spring and Fall 2010 offerings.

Name: Meulenberg, Robert

Worked for more than 160 Hours: No

Contribution to Project:

Dr. Meulenberg is a new assistant professor in Physics at UMaine, who performs research on the photonic and magnetic properties of quantum dots. He presented a tutorial to the class on the fundamental physics of quantum dots and a summary of his current research activities.

Research Experience for Undergraduates

Organizational Partners

Other Collaborators or Contacts

Dr. Smith has had ongoing discussions with Dr. James Vesenka, Professor of Chemistry and Physics at the University of New England, regarding the participation of students in his program in the Nanoscale Science and Engineering course. They have exchanged laboratory procedures for AFM demonstrations for middle school students and are planning a summer mini-course in Nanotechnology for students at UNE. In addition, Dr. Smith is collaborating with Doughty middle school teacher, Patricia Bernhardt, to develop a nano module for her biology class. To date, Dr. Smith has visited the Doughty middle school on four occasions, presenting basic concepts of Nanoscale, AFM imaging, and thin films to the science club and to students in Math, Chemistry and Biology classes.

Activities and Findings

Research and Education Activities: (See PDF version submitted by PI at the end of the report)

The major activities during this project have been
a) A new nanoscience and engineering course was developed and offered four times, enrolling a total of 53 undergraduate engineering majors at UMaine. The course involved the instructional participation of 12 science and engineering faculty, 1 education associate and 4 graduate students. Twelve laboratory modules were developed which included hands-on activities and demonstrations.

b)For each of 3 consecutive summers, 15 high school students were hosted by the PI in her laboratory for three days for the Consider Engineering program (45 students total). Students participated in projects that involved fabrication and assembly and test of devices, collection and analysis of test results, and presentation preparation and delivery to an audience of other students, parents and teachers. Projects included an optical heart-rate monitoring sensor and circuit, a microfluidic mixer, and a dye sensitized solar cell.

c) The PIs led over a dozen tours of the nanofabrication facilities at UMaine to more than 300 middle school students from all over the State of Maine.

d) PIs hosted two female REU students in their research laboratories during Summer 2010: Jamie Reinhold, Electrical Engineering Major at UMaine and Gabrielle Grandchamp, Chemistry major at Brown University. Jamie microfabricated and tested a miniature pressure sensor in Parylene and Gabrielle made and demonstrated a microfluidic droplet generator. Jamie graduated with a BS degree in May 2010 and is now an MS candidate in Electrical Engineering at UMaine.

e) Dr. Smith has hosted and instructed over 100 middle school girls in a hands-on, blinker circuit assembly lab, where each girl assembled her own blinker circuit to take home.

f) Dr. Collins developed a Nanoscience course for upper division undergraduate/ first year graduate students in Chemistry, which is being offered Spring 2012.

g) Dr. Smith led discussions about Nanotechnology, gave AFM and SEM demonstrations, and organized hands-on activities with more than 400 K-12 students who have visited the UMaine campus during the past 3 years.

Findings:

Despite increased student enrollment in the course, enrolling 1st year engineering students in the course continues to be challenging. Many of the in-coming students express interest in taking the course, but can not fit it into their tight schedules. The course was offered in Fall 2009, Spring 2010, Fall 2010, and Fall 2011. It was opened up to all engineering undergraduates, and an ethics credit component was added, which resulted in a significant increase in enrollment. According to the assessment results, the course is well-liked by the participating students. In particular, many students commented that they like the hands-on laboratories and wish that more of their engineering courses would have accompanying demonstration and hands-on activities. However, the majority of the enrollment in the course has been from 3rd (50%) and 4th year students (about 20%), and 20-30% are in their 2nd year- less than 10% have been first year students. This broad range of preparedness has necessitated that each tutorial be carefully developed to include both very basic and more advanced content. However, scheduling of the lab sections was very difficult due to the multi-program and multi-year enrollment. Also, the labs were found to work best in terms of providing each student with hands-on opportunities with six or fewer students in a 1.5 hour period.

The course tutorials were meant to expose the students to a wide range of nanotechnology topics. A final term paper was assigned in which each student would examine in greater detail a nanoengineering topic of personal interest, with the goal of engaging each student in an independent exploration. With the wide range of the students level of college education, the term paper challenge was met with an equally varied amount of success. The 'finding' was that undergraduate engineering students have in general very poor writing skills and receive too little training in how to write a research or technical paper.

Another finding was that prior to taking the course, the engineering students at UMaine had little understanding of nanoscience. The concept of nanoscale was familiar, but the consequences of nanoscale were unknown. Most of the students related nanotechnology to microscopic robots. At the end of the course, based on the results of the weekly quizes and term papers, all of the students grasped the concept of size dependent behavior.

Although the course format was well-received by the students, the work-load and expense of the lab experience and scheduling is not conducive to expansion, i.e. class enrollment increasing over 24 students. A new approach is being taken by the PIs in a newly granted NUE project, wherein the existing course content will be modified for delivery to upper division undergrads and first-year graduate students, and content from the current tutorials and labs will be extracted for insertion into existing first year intro engineering courses in each department. This approach will enable much wider exposure, reaching every 1st year engineering student.

Training and Development:

Senior Personnel:

All senior personnel have developed teaching skills and gained experience in transferring high level knowledge about nanoscale science and engineering to high school and undergraduate college students.

Undergraduates:

Mr. Cota and Mr. Demers each gained experience in preparing and giving laboratory instruction. Each has helped to develop lab materials and have performed demonstrations and trained other students in operation of equipment. Ms. Reinhold and Ms. Grandchamp received research training during their REU program in nano and microfabrication.

Graduate students:

Mr. Spinney and Ms. Duy are both PhD candidates at UMaine. They assisted in developing laboratory experiences and led hands-on instruction of undergraduate students in the lab. They have received training in this instruction from the PIs, including help with laboratory procedure/manual preparation, discussions on how to present advanced material to undergraduates, side-by-side laboratory instruction of students with the professor, and finally solo laboratory instruction of students.

Outreach Activities:

The PI visited multiple public schools in Maine, where she presented solar energy, thin film technology and AFM imaging and led students through hands-on activities that demonstrated nanoscale and nanoscience concepts.

The PI visited Biddeford HS, in southern Maine, in November 2009, with solar energy and AFM imaging demonstrations.

A visit to Doughty Middle School by the PI and Tim Garay, TA, took place on June 15, 2009. They discussed nanotechnology with over twenty, 7th and 8th grade students, and demonstrated AFM imaging of a compact disk.

During July, 2009, the PI hosted three groups of 5 HS students each, in her laboratory, to learn about nanotechnology and applications to solar energy. Each group spent two days making and testing a solar cell that uses TiOx nanoparticles and raspberry juice to generate electrical power upon exposure to sunlight. They compared the performance of the raspberry juice device to a commercial, silicon solar cell, and presented their results to other students and faculty.

On September 28, 2009, the PI gave a presentation about nanotechnology, sensors and solar energy to over twenty girls from McAuley HS, an all-girl, private high school in southern Maine.

Dr. Smith also hosted McAuley HS physics teacher, Jamie Schwellenbach, for a one day discussion about potential hands-on, engineering projects for her students. A nano solar cell laboratory module is being developed for a combined Chemistry and Physics, year-long project for junior and senior students.

Mrs. Tricia Bernhardt, a biology teacher at Doughty middle-school in Bangor, ME, spent two days in Dr. Smith's laboratory, learning about AFM imaging. Dr. Smith and Mrs. Bernhardt are developing a DNA extraction and imaging procedure that can be incorporated into the biology classroom.

The PIs hosted two female undergraduates in their research laboratories during Summer 2010 as REU participants.

During July, 2009, the PI hosted three groups of 5 HS students each, in her laboratory, to learn about optical sensing of heart rate, assembled a sensor and associated circuitry, and made measurements using the sensor of their heart rates after different levels of physical of activity.

Dr. Smith gave tours to HS students from Skowhegan ME, McCauley HS and Hampden ME in November 2010. She also led a discussion on nanotechnology and gave an AFM demonstration to visiting students from John Bapst HS in November 2010.

Dr. Smith made 3 visits to Doughty Middle School in Bangor, Maine, during the Spring and Fall of 2011, where she led students in Math and Science classes in a hands-on iridescent film making and explanation activity, demonstrated an AFM and gave a tutorial on powers of 2 and 10 and the nanoscale. During each visit, 12-20 students participated in the activities.

In February 2010, 120 middle school students visited the PIs labs as part of a college-wide Making Stuff / Nano Days event. They saw a presentation on nanotechanology, viewed live images from a scanning electron microscopy, and made their own iridescent thin films.

During the Spring and Fall of 2011, over 120 middle school girls assembled their own LED blinker circuits.

Journal Publications

Books or Other One-time Publications

Web/Internet Site

URL(s):
http://www.eece.maine.edu/Nano-TEEM
Description:
This is the course website.

Other Specific Products

Contributions

Contributions within Discipline:
The course developed in this project involved the participation of twelve faculty from five departments: Electrical& Computer Engineering, Chemistry, Mechanical Engineering, Physics, and Chemical& Biological Engineering. We have developed a working model for cross-disciplinary instruction around a common theme: nanoscale science and engineering. Before the start of each semester in which the course was offered, we met and discussed the content, scheduling, and proposed changes from the previous offering. Each laboratory experience is linked to the topic covered in the tutorial that week, and each instructor provides input and/or assistance in delivery of the lab module. This has included supplies, student research assistants, laboratory equipment, space and demonstrations. The course was the first at UMaine with such a large extent of hands-on experiences, multi-department participation in instruction, and cross-college offering to undergraduates. The course has inspired the development of a new, cross-college offering in sustainable energy and discussion of a cross-college course in engineering ethics.

Contributions to Other Disciplines:

Contributions to Human Resource Development:
The course has contributed to human resource development in engineering, science and technology by training students, early in their college careers, in the fields of nanoscience and nanoengineering.

Two undergraduate engineering aids, and three graduate students, have received training in nanoscale science and in methods of educating others about this field.

Senior personnel are learning how to better educate undergraduate students about nanoscience and nanotechnology.

Several hands-on activities and demonstrations pertaining to Nanoscience were developed that continue to be delivered to numerous, visiting groups of K-12 students from all over Maine. To date, over 350 children have participated in at least one activity.

Contributions to Resources for Research and Education:

A teaching laboratory has been established and continues to be updated and equipped for instruction in nanotechnology.

An on-line course assessment was developed in collaboration with Dr. Brian Doore of the Education Department, and applied to students who took the course in Spring 2010 and Fall 2010. A new assessment tool is being developed for pre-college students to evaluate the level of awareness and knowledge students have prior to taking the course or participating in outreach activities.

A hands-on microfabrication laboratory was developed and offered in May 2010 as a companion to an existing Microelectronics Science and Engineering course. Nine students spent 3 full days in the microfabrication cleanroom and successfully fabricated field effect transistors and circuits. Student aids for this course received training in both methods and teaching through the NUE project which enabled this laboratory to be successfully developed and delivered.

Contributions Beyond Science and Engineering:

Conference Proceedings

Categories for which nothing is reported:

Organizational Partners

Any Journal

Any Book

Any Product

Contributions: To Any Other Disciplines

Contributions: To Any Beyond Science and Engineering

Any Conference

Introduction to Nanoscale Science and Engineering (GEE 298)

Summary of tutorials and laboratory experiences developed to date:

Tutorials

Title	Presenter	Date Delivered
Intro to the Nanoscale: Size and Scale	R. L. Smith (ECE)	9/ 9/08
Nanoelectronics and Photolithography	D. Kotecki (ECE)	9/16/08
Biomolecules in Micro and Nanoscale Devices	P. Millard (CBE)	9/23/08
Nanofabrication Methodologies	R. L. Smith ECE)	10/02/08
Amphiphilic Molecules and Self -Assembly	D. Neivandt (CBE)	10/07/08
Nanoparticles	*M. Mason (CBE)*	*10/21/08*

Laboratory Experiences

Title	Lab Leaders	Date Delivered
Tour of LASST Nanofabrication and Characterization Facilities	G. Bernhardt (Phy) R. L. Smith (ECE)	9/04/08
Scanning Electron Microscopy	G. Bernhardt, R. L. Smith	9/11/08
Photolithography and PDMS molding	R. Cota (ECE), G. Bernhardt	9/18/08
PDMS Stamping of Biomolecules	P. Millard (CBE), R. L. Smith	9/25/08
Surface modifications, L-B trough	D. Neivandt (CBE), S. Sterling	10/9/08
Focused Ion Beam and SEM	S. D. Collins (CHE), R. L. Smith	10/16/08