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An Interdisciplinary, Research-intensive Minor in Nanotechnology Studies

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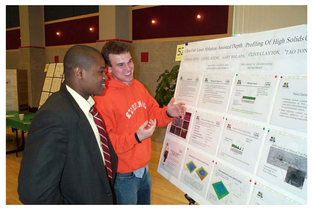
Project Abstract

At Stony Brook University, with support from NSF-NUE, we have established a new undergraduate minor in Nanotechnology Studies (NTS), an interdisciplinary, research-intensive program intended for students in all majors from the College of Engineering and Applied Sciences and the College of Arts and Sciences who want to learn about the emerging field of nanotechnology. The NTS minor is unique in its ability to attract undergraduate students from a broad range of academic backgrounds, to integrate into existing majors and programs through mentored research, and to foster professional development through teamwork, communications and active learning. The coursework in the Minor provides a broad background in the science, design, manufacture, and societal, health and environmental impacts of nanomaterials and nanoscale structures and their applications in engineering and health-related areas. The inclusion of a minimum of two semesters of research in the students' own major areas, as well as choice of technical electives, allows for integration into current interests and disciplines, and provides knowledge and skills valuable to students planning to seek employment or graduate studies in fields related to the engineering, business, policy or broader impact of nanotechnology. In its first year, the program has been further developed through interactions with an expanding group of departments and academic programs, as well as through integration with current University outreach programs and newly funded educational initiatives which explore the impact of global issues on technology and education.

Educational Goals and Learning Outcomes

Overall goals: The proposed minor and other program activities will facilitate and promote;



- Learning comprehension in basic principles of nanoscience and nanoscale engineering
- Understanding applications of nanotechnology to engineering and medical systems
- Student engagement and motivation
- Interdisciplinary experience and teaming
- Generating a supportive, integrated learning community -- a mirror of the "community of scientists" which provides the structure for scientific advancement.
- Development of an appreciation for life-long learning
- A global understanding of the impacts and issues regarding nanotechnology and applications

Specific Course Learning Objectives: In addition to the overall program in Nanotechnology Studies, two courses have been developed specifically for the Minor: Introduction to Nanotechnology Studies (213) and Nanotechnology and Research (400). Both have been reviewed by an engineering college-wide committee (with representation from all Departments in the College of Engineering and Applied Sciences at Stony Brook University) and are now incorporated in the offerings of the University. Learning objectives for these two courses are:

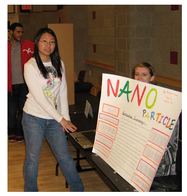
Learning objectives of the **Introduction to Nanotechnology Studies** course include:
- Understanding basic interdisciplinary nature of nanotechnology; (physics, chemistry, electronic and mechanical properties, bionanotechnology)
- Understanding societal impact and managing possible risks of nanotechnology: present and future.
- Understanding some of the basic research tools and techniques involved in nanotechnology research and manufacturing
- Having enough of an introduction to see how student interests are connected to nanotechnology and how students can get involved in nanotechnology research

Learning objectives of the **Nanotechnology and Research** course include:
- Understanding the professional research enterprise
- Writing a journal-quality manuscript
- Write a research proposal in response to an RFP
- How to find funding sources
- How to be a research mentor
- Making professional presentations on research (culminating in presentation at **Nanotechnology Studies Undergraduate Research Symposium**)

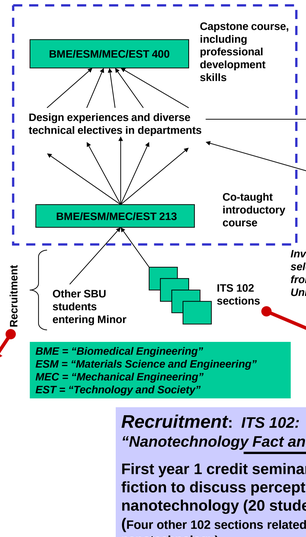
Education Goals, Learning Outcomes and Program performance are reviewed periodically by the NTS faculty committee and the External Advisory Board, composed of education researchers, outreach specialists and two representatives from nanotechnology companies (including a CEO).

Approach/ Methods

***Recruitment*: Activities at University and College of Engineering and Applied Sciences programs**



First year students from WISE (Women in Science and Engineering)



Structure of the NTS program: recruitment, course design, research

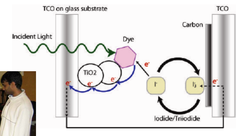
Recruitment*: *ITS 102: "Nanotechnology Fact and Fiction"

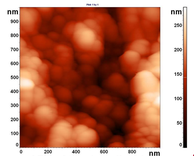
First year 1 credit seminar using science fiction to discuss perceptions of nanotechnology (20 students per year) (Four other 102 sections related to nanotechnology)

***Course design*: Introduction to Nanotechnology Studies: A co-taught, cross-listed course in the science and applications of nanotechnology, as well as societal impact, safety and business issues**

Class project: hands-on design and analysis of nano-crystalline, dye-based solar cells

- Students learn about materials, business, risks and use analytical techniques (atomic force microscopy, electron microscopy and Raman microspectroscopy)

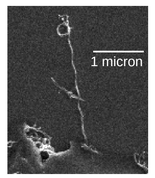


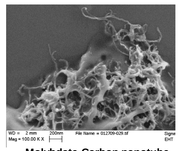


AFM of titanium dioxide nanoparticles

***Research*: Students perform independent research projects related to nanotechnology applications in their area of study**

ESM499: Independent research on Design of Carbon Nanotube Structures, Chemistry and Applications





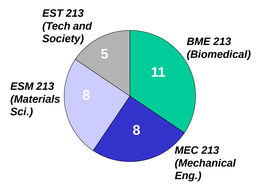
Molybdate-Carbon nanotube reactions

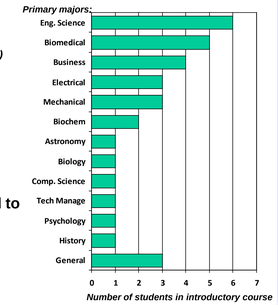
Examples of current undergraduate research projects for NTS:

Jonathan Hu	Mechanism of Metal Nanoparticle Formation in Isopods
Jason Kubasky	Silver Nanoparticle Coated Thin Layer Chromatography Plates
Scot Perl	Chemistry of Water in Nanopores
Juan Pinales	Molybdate Catalyzed formation of Carbon Nanotube Structures
Yingbin Li	Nanocrystalline Dye Sensitized Solar Cells
Polly P. Lo	Mechanical and Erosive Damage in Dental Enamel Microstructure

Preliminary Outcomes

Introductory course held twice (Spring 2008, Fall 2008) for a total of 32 students: the distribution of students in the class can be summarized both by the course designator for which they registered, as well as their major areas:





A broad range of students attracted to the program.

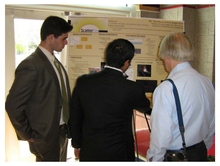
Distribution of course designators enhances institutionalization (and sustainability) of the program.

Feedback from students in the program is overwhelmingly positive and participation is growing:

Student responses to Student Assessment of Learning Gains and interviews with external evaluator indicate that: (i) learning objectives were met, most strongly in the areas of understanding nanotechnology concepts, the interdisciplinary nature of nanotechnology, and the ethics, environmental, health and business implications of nanotechnology, (ii) students felt learning best supported by hands-on activities, guest speakers, and (iii) students felt this course very much added to their appreciation of the field, and would like to take more courses in this area.

The first annual Nanotechnology Studies Undergraduate Research Symposium was held in conjunction with the campus-wide "Celebration of Undergraduate Research and Creative Activities" on April 30th, 2008. The program (images at left) included student speakers and posters detailing undergraduate research activities related to nanotechnology.

To generate a greater variety of research opportunities for NTS students, we are working with faculty in business, computer science, biology and other less traditional sources to develop collaborative research projects.



The first year achievements of the NTS program have been reported at the annual meeting of the American Society for Engineering Education and are published in the peer-reviewed proceedings:

G.P. Halada, M. Frame, C. Korach and D. Ferguson, An Interdisciplinary, Research-Intensive Minor in Nanotechnology Studies, Proceedings, American Society for Engineering Education, 2008 ASEE Annual Conference & Exposition June 20 - 25 - Pittsburgh, PA (2008).

-- nominated for best paper award, Multidisciplinary Engineering Division

Broader Impact and Project Expansion

- Interactive website developed, which includes on-line virtual conference room (using Adobe Connect), research opportunity dissemination and undergraduate research highlights: **www.stonybrook.edu/nanotech**
- Expansion through new collaborations with Departments which were not original participants (Physics, Chemistry, School of Business)
- Related projects being developed for K-12 outreach (with Brookhaven National Laboratory), teacher education, advanced technical training for local industry and graduate student training
- NSF-Science Education for New Civic Engagements and Responsibilities (SENCER) implementation project: **The Impact of Socio-Economic Diversity on the Global Development and Deployment of Nanotechnology and Other Emerging Technologies**
  - Joint project with Departments of Electrical Engineering, Biomedical Engineering, Technology and Society, and the program in Engineering Science
  - Enhance nanotechnology education through exploration of applications to societal needs in the developing world

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