THE UNIVERSITY OF RHODE ISLAND
COLLEGE OF ENGINEERING

NUE: Interdisciplinary Nano Tools Course at the University of Rhode Island

Vinka Oyanedel-Craver
Civil and Environmental Engineering
Geoff Bothun
Chemical Engineering

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NUE: Interdisciplinary Nano Tools Course at the University of Rhode Island

- NUE program and overall trends
- Motivation for Nano Tools
- Proposed curriculum – A “tools-up” approach
- Proposed assessment
- Future work

NUE: General trends

- NUE program goals:
  - Integrate advancements in nanoscale science, engineering, and technology into the undergraduate engineering curricula
  - Address educational challenges and generate practical ways of introducing nanotechnology into undergraduate engineering education with a focus on devices and systems and/or on social, economic, and ethical issues relevant to nanotechnology
- Total number of awards since 2002: 182
- Active awards: 41
- States with NUE: 39 + DC and PR
- Emphasis concepts introduction, environmental and ethical implications

Nano Tools: Motivation

- Nanotechnology education is critically needed to create a skilled domestic workforce to achieve and sustain this growth

Actual and estimated growth of nanotechnology
(NSF WTEC report "*Nanotechnology Research Directions for Societal Needs in* 2020)

	United States (*World*)	
	Primary workforce	Final products market
2000	25,000 (*60,000*)	$13 B (*$30 B*)
2008	150,000 (*400,000*)	$80 B (*$200 B*)
2000-2008	25%	
2015	800,000 (*2,000,000*)	$400 B (*$1,000 B*)
2020	2,000,000 (*6,000,000*)	$1,000 B (*$3,000 B*)

Nano Tools: Objectives

- To develop nanotechnology competences and professional skills in undergraduate students within STEM majors at the University of Rhode Island by exposing them to state-of-the-art instruments commonly used in nanotechnology.
  - To provide basic knowledge of the principles and operation of nanoscale instrumentations.
  - To foster problem-based, peer-to-peer learning through research-oriented group proposal projects.
  - To enhance students' technical communication skills through group presentations, journal-formatted project reports, and online learning and professional portfolios.
  - To enhance student-faculty and faculty-faculty collaborations to create new research opportunities after the course.
  - To expose students to societal, ethical, economic, environmental, and entrepreneurial/commercial implications of nanotechnology through topical seminars.

Nano Tools: ABET

Specific objective	ABET Outcome
Develop an interdisciplinary course that provides basic knowledge of the principles and operation of *Nano Tools*. • *Demonstrate a working understanding of inter-nanoparticle interactions that govern colloidal stability* • *Demonstrate an understanding of the principles and basic operation of the tools covered* • *Identify complimentary information that can be gained from the use of the tools for nanoparticle characterization*	*(a) an ability to apply knowledge of mathematics, science, and engineering* *(b) an ability to design and conduct experiments, as well as to analyze and interpret data* *(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice*
Foster peer-to-peer learning through laboratories and problem-based research projects. • *Develop an experimental design that applies Nano Tools to solve an independent research project*	*(b) an ability to design and conduct experiments, as well as to analyze and interpret data, (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice*
Enhance students' technical communication skills. • *Demonstrate an ability to self-directed learning, self-reflex of class material and a gain of nanotechnology competences toward professional development* • *Demonstrate an ability to communicate results to an interdisciplinary audience.*	*(g) an ability to communicate effectively* *h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context*
Enhance student-faculty and faculty-faculty collaborations. • *Create new opportunities for collaboration and student training.*	*h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context*

Nano Tools: Overview

Week 1		Introduction to nanotechnology		
Weeks 2-3	 Dynamic light scattering (DLS)	Physical characterization of hard or soft nanoparticle dispersions	*How nanoparticle composition and dispersing medium determine inter-nanoparticle interactions and colloidal stability*	
Week 4		Societal, ethical, and economic implications		
Weeks 5-7	 Transmission electron microscopy (TEM)  Scanning electron microscopy (SEM)	Physical and chemical characterization of hard or soft nanomaterials and nanoparticles Cryogenic studies of nanoparticle dispersions	*How direct imaging under dry or wet (cryogenic) can reveal microstructure and dispersibility* *How composition can be quantified and connected to microstructure*	**Weeks 4-10** Interdisciplinary group proposal projects: Proposal planning, communication skills, and laboratory training with faculty mentors and their graduate students
Week 8		Environmental health and safety implications		
Weeks 9-10	 Atomic force microscopy (AFM)	Physical characterization of hard or soft nano-material surfaces	*How inter-nanoparticle interactions govern film deposition and morphology*	
Week 11		Nanotechnology entrepreneurship and commercialization		**Weeks 11-15** Proposal development, preliminary data, and presentations

Figure 1. An overview of the interdisciplinary URI *Nano Tools* course. Green boxes in weeks 4, 8, and 11 denote periods where the PIs and invited speakers will give topical lectures related to the broader impacts of nanotechnology. Black boxes denote periods where technical lecture and laboratory content will be provided on *Nano Tools*. Red boxes denote activities related to independent research proposal planning and development.

Students will synthesize Au nanoparticles in lab 1 and use the tools to characterize.

Changing solution conditions will demonstrate surface forces (for example).

Nano Tools: Highlights

- We propose to incorporate four crucial *Nano Tools* available across the URI campus within this course: Dynamic light scattering (DLS), transmission electron microscopy (TEM), scanning electron microscopy (SEM), and atomic force microscopy (AFM).
  - URI and COE supported the AFM purchase and supports part-time staff positions for the SEM and TEM.
- *Nano Tools* course will integrate lectures, laboratory sessions, and student-driven research proposal projects.
  - Fundamental principles will be taught from lectures, seminars and equipment overviews
  - Students will have opportunities to operate state-of-the-art instruments during laboratory sessions.
  - Five faculty members who are conducting NSF-supported projects will participate as mentors to supervise research projects and mentor

Nano Tools: Highlights

- Experiential Learning and Community Engagement at URI to help the students to develop career portfolios to track there skills development and to assess the performance of the students with the faculty mentors as mini-internship (http://web.uri.edu/experience/).
- Metcalf Institute will provide communication training to students for public communication of nanotechnology issues (http://metcalfinstitute.org)
- John Hazen Sr. Center for Ethic and Public Service at URI will help with seminar preparation regarding ethical implication of nanotechnology.
- Rhode Island Nanotechnology Consortia will engage members to participate in seminar and round tables about additional complementary technical topics (http://www.uri.edu/nano/)
- Collaboration with the Business Engagement Center at URI for session about entrepreneurship and commercialization

Nano Tools: Assessment

- Program Director at the Center for Human Services/College of Human Science and Services at URI will perform external assessment

- The formative evaluation:
  - *Scientific ability rubrics:* Students will be assessed in topic such as design and performance of experimental activities, collection and analysis of data, critical comparison of information and scientific communication (http://paer.rutgers.edu/ScientificAbilities/Rubrics/default.aspx).
  - *Standard course evaluation tools:* IDEA-SRI survey.
- Several sources will be used to prepare the summative evaluation.
  - *Pre and post surveys*
  - *Focus groups*.
  - *Senior exit interviews*
  - *Participant tracking*

Nano Tools: Conclusions

- EGR 450X: Nano Tools approved by faculty senate, to be offered for first time next semester **(spring 2014)**.
  - A “tools-up” approach that conveys nanoscale concepts by first focusing on how a tool works and what properties it can measure (and why).
- From paper to implementation
- Future support

Questions?

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ABET Criterion 3. Student Outcomes (a-k)

The program must have documented student outcomes that prepare graduates to attain the program educational objectives.

Student outcomes are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program.

a. an ability to apply knowledge of mathematics, science and engineering
b. an ability to design and conduct experiments, as well as to analyze and interpret data
c. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
d. an ability to function on multidisciplinary teams
e. an ability to identify, formulate, and solve engineering problems
f. an understanding of professional and ethical responsibility
g. an ability to communicate effectively (3g1 orally, 3g2 written)
h. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
i. a recognition of the need for, and an ability to engage in life-long learning
j. a knowledge of contemporary issues
k. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.