Recommended Features for an NSE Degree Program: Common Features Identified from Three Studies

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Nanoscience Learning Goals Workshop 2006

- NSF-funded joint SRI/NCLT workshop held June 2006 at SRI International
- 39 participants, leading scientists and science educators in nanoscale science and engineering, learning science, science education and informal education
- Participants identified and clarified the big ideas in NSE appropriate for grades 7-12

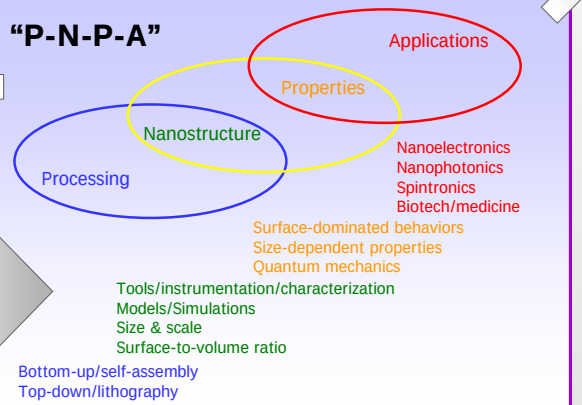
Nanoscience Learning Goals Workshop	NCLT Faculty Workshop
Size & scale	Size & scale
Properties of matter	Size-dependent properties
Dominant forces	Surface-dominated behaviors
Particulate nature of matter	Quantum mechanics
Tools	Tools/instrumentation/ characterization
Modeling	Models and simulations
Technology and society	Societal impact/public education
Self-assembly	Self-assembly

S. Stevens, L. Sutherland, P. Schank, and J. Krajcik, "The Big Ideas of Nanoscience" (preliminary report)

NCLT Faculty Workshop 2006

- August 2006 at Cal Poly State University, San Luis Obispo
- 32 faculty participants from 17 schools (8 participants from community colleges, 24 from universities) across the country and Puerto Rico
- Participants identified big ideas and learning goals in NSE at the undergraduate level (grades 13-16)
- Strong overlap with SRI/NCLT workshop findings

Big Ideas and Learning Goals in NSE



Cross-cutting issues

Importance of biology/life sciences
Importance of models/simulations
Interdisciplinarity of nano
Societal impact/public education
Safety issues/hands-on experience

Major observations

- Tools/instrumentation/characterization frequently mentioned, both in big ideas and learning goals.
- Quantum mechanics was thought essential for teaching NSE at the undergraduate level.
- More attention was given to nanostructure vs. properties relationship than to processing and applications, which deserve greater attention.
- Societal impact was rarely mentioned in science courses.
- Biology and the life sciences are essential to nanotechnology. (Note: Many engineering schools do not require biology at the undergraduate level)

Boeing/SRI Study 2006/2007

- Objective: to identify learning outcomes relevant to post-secondary education and compare them with industry needs as specified by Boeing and analysis of industry
- Study conducted through survey of industry needs, analysis of university-level courses, and interviews with university faculty
- Strong overlap with the other studies

Required nanotechnology competencies

- Nanofabrication
- Characterization/modeling of nanostructure
- Surface chemistry and engineering
- MEMS, sensors, micro/nano devices

P-N-P-A

- Processing
- Nanostructure
- Properties
- Applications

Findings re: college courses/programs

- Mismatch between industry needs and skills of university graduates
- Lack of interdisciplinary preparation
- Lack of course coherence in 4-year institutions
- Disconnect between survey courses and advanced electives
- Training tends to be theoretical rather than practical

A. Rosenquist, S. Stevens, R. Cormia, V. Dang, D. Drane, N. Sabelli, and J. Krajcik, "Nanoscience: A Vehicle for a Goals-Oriented Science Education" (preliminary report)

Recommended Features for an NSE Degree Program

- **Programmatic balance**
  - Processing/nanostructures/properties/applications (P-N-P-A)
- **Interdisciplinarity**
  - Science (including biology) and technology
- **Integrated classroom-lab experience**
  - Hands-on use of advanced instrumentation
- **Curriculum linked to applications**
  - Balance between theory and practice (industrial needs)
- **Content addressing societal impact: public safety, ethics, and awareness**

Evaluation of Existing Programs

- Based on course descriptions of degree programs on the NCLT website (www.nanoed.org/degree/degree.html)

Institution	Degree Program
California Polytechnic State University, CA	B.S. with electives in nanotechnology
Clarion University, PA	Minor in nanotechnology
Dakota County Technical College, MN	A. A. S. degree in nanoscience technology
North Seattle Community College, WA	A. A. S. degree in nanoscience technology
Northeastern University, MA	Ph. D. in Nanomedicine Science and Technology
Northwestern University, IL	Area of concentration in nanoscale physics, B.S. in Physics
Rice University, TX	Ph. D. with concentration in nanophotonics
University of California, Berkeley, CA	Designated emphasis in NSE
University of New Mexico, NM	M.S./Ph. D. in nanoscience and microsystems
University of Washington, WA	Optional Ph. D. in nanotechnology

- Dedicated interdisciplinary nanotechnology programs are rare. Rather "nano" is a minor, emphasis or option within a traditional discipline.
- Few programs offer programmatic balance (P-N-P-A). Students can achieve balance by their choice of electives or concentrations.
- Technical colleges emphasize hands-on fabrication methods and characterization tools, with less exposure to nanostructure-property relationships (e.g., quantum mechanics)
- Research universities emphasize nanostructure-property relationships, with less attention to one end (processing), the other (applications), or both. Students can achieve balance by their choice of electives or concentrations.
- Engineering aspects such as design of devices and process optimization are rarely taught.
- Societal impact issues (safety, ethics, awareness) are underrepresented in existing degree programs.