A Nano^Leap^ Into New Science

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Abstract

Nanoparticles are being used in an ever-expanding number of industries—electronics, pharmaceuticals, and energy, just to name a few. A 2001 National Science Foundation report, "Societal Implications of Nanoscience and Nanotechnology," projected that as many as 2 million workers may be needed to support nanotechnology industries worldwide within 15 years. Clearly, we are standing at a critical juncture, or even in the midst of an industrial revolution. Now that nanotechnology has arrived, how do we prepare and educate our future workforce?

The NanoLeap project is breaking new ground by developing and evaluating instructional materials that teach high school students about nanoscale science! The curriculum modules, entitled A NANOLEAP INTO NEW SCIENCE, will include student activities, experiments, and assessments for use as replacement units in high school physical science and chemistry courses. Accompanying resources and professional development for educators will be included to facilitate implementation of the modules. Materials will undergo pilot and field testing, thereby providing project staff with useful data to inform the development and implementation processes. A summative evaluation will assess the effectiveness of the project in achieving its articulated goals and impact on student achievement and teacher practice.

Project Goals

1. To explore where nanoscale science, technology, engineering, and mathematics concepts can fit into high school physical science and chemistry classes in a manner that supports students in learning core science concepts.
2. To determine a viable approach for instructional materials development in the areas of nanoscale science, technology, engineering, and mathematics.

The Process

NanoLeap's Big Ideas

Properties of Matter
Surface interactions can dominate, and changes in properties can arise at the nanoscale size.

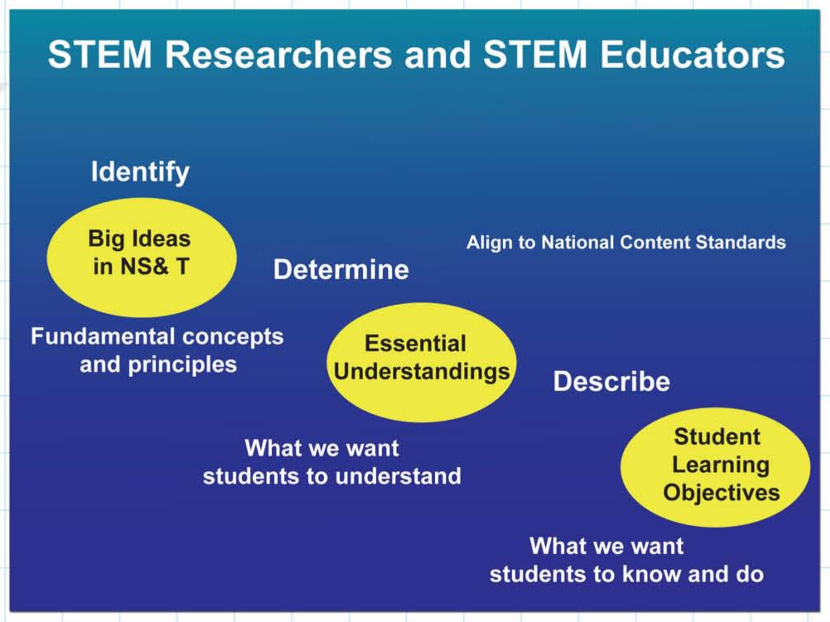
Forces
Electrical and magnetic forces are the most important of the fundamental forces at the nanoscale level.

Energy
The flow of energy in large part drives processes of change in biological and chemical systems.

Measurement and Size
Imaging and measurement tools allow for detection, characterization, and manipulation of nanostructures.

Interdisciplinary Nature of Nanoscale Science
The nature of nanoscale science, technology and engineering is interdisciplinary.

Ethical and Social Issues of Nanoscale Science and Technology
Social interactions can occur between scientific and engineering communities and society.



Preliminary National Survey

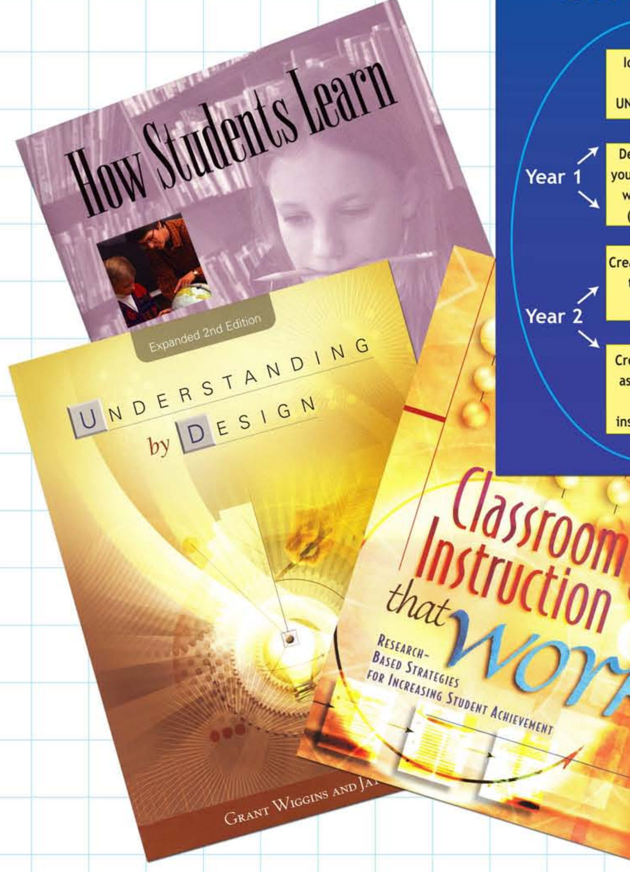
Between Fall of 2004 and Spring of 2005, 307 teachers nationwide responded to the NanoLeap online survey, which sought to find out:

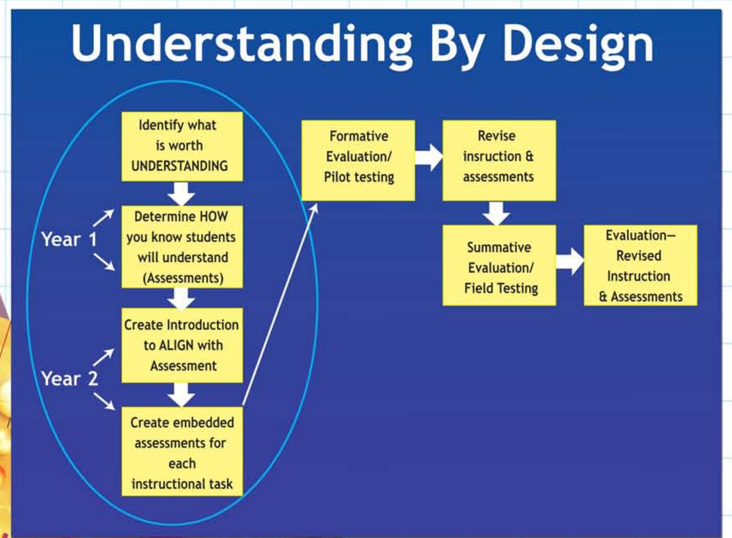
(1) the relative importance of the underpinning concepts that might support the teaching of nanoscale science concepts in the high school curriculum;

(2) where potential nanoscience concepts can be taught in high school; and

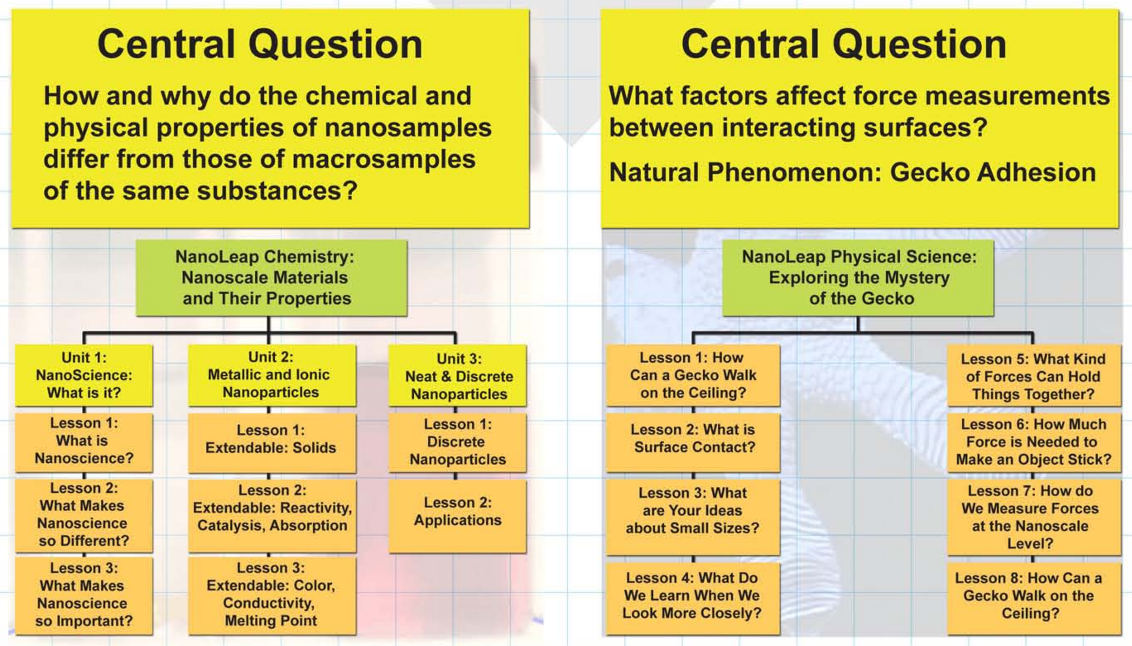
(3) how likely teachers are to use nanoscience instructional materials.

Instructional Design





Modules Overview



Professional Development

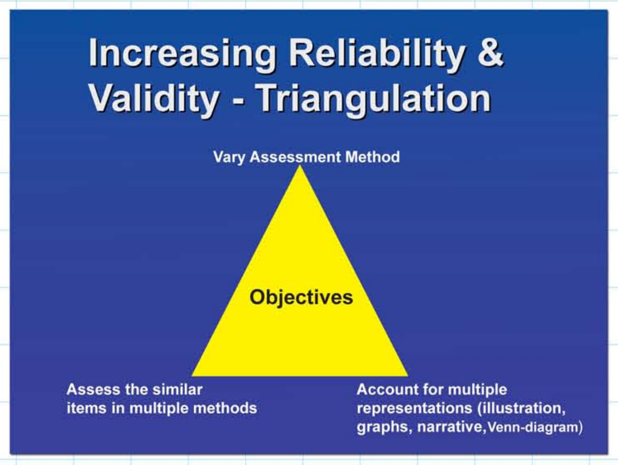
Mission: To assist teachers in successfully implementing the NanoLeap Series within the context of their local settings and to accomplish these goals:

- *Increase teacher understanding of nanoscale science and engineering content, awareness of the essential interdisciplinary nature of nanoscience, and recognition of the value the field brings to a standards-based science curriculum*
- *Strengthen teacher capacity for implementing a NanoLeap module with inquiry activities and research-based instructional strategies*

The NanoLeap A Team, selected through a rigorous application process, is composed of sixteen master teachers who co-develop and pilot test the instructional modules.

Assessment

- Align objectives and assessment method with target knowledge to be assessed
- Formative: student journals and student handbooks
- Summative: pre- and post-treatment multiple-choice assessments
- Summative: essay and poster assessments



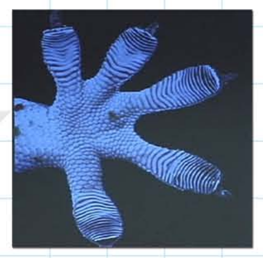
Project Timeline

2004	2005	2006	2007	2008
Start of Funding	Development A Team	Pilot Testing A Team	Field Testing B Team	Evaluation

Multimedia www.mcrel.org/nanoleap/multimedia

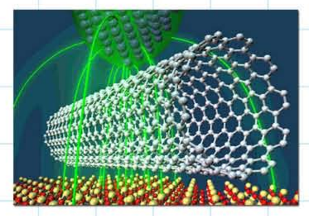
NanoLeap Remote Access Activities

Tricky Feet Video

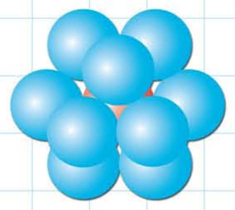


NanoScale Me Interactive

NanoSize Me Video



Nanoparticle Builder Interactive



Atomic Force Microscope Video

Student Learning Data

A total of 1,380 students participated in the NanoLeap field test. Of these, 766 students participated in the physical science field test, 315 in the treatment group and 451 in the control group. Another 614 students participated in the chemistry field test; 299 in the treatment group and 325 in the control group.

Students in the physical science and chemistry field tests completed a pre- and post-test to assess their knowledge of core science and nanoscale science concepts within the particular subject area.

Table 1: Physical Science Student Assessment - Overall and By Science Content, 2007-2008 Field Test

		Treatment (n=306)			Control (n=343)			Difference Treatment - Control		
Mean (S.D.)	Items	Pre	Post	Gain Score	Pre	Post	Gain Score	Pre	Post	Gain Score
Total Score (42 items)	1-42	19.5 (6.2)	24.9 (8.0)	5.4 (6.1)	18.7 (6.0)	19.5 (7.6)	0.8 (6.1)	0.9 (0.5)	5.5 (0.6)	4.6 (0.5)
Effect Size				**0.76***			0.12	0.13	**0.69***	**1.02***
Core Science (21 items)	1-3, 7, 9-13, 17, 20, 23, 24, 32-37, 41, 42	10.3 (3.5)	12.4 (4.2)	2.1 (3.7)	9.9 (3.7)	10.3 (4.4)	0.4 (3.6)	0.4 (0.3)	2.1 (0.3)	1.7 (0.3)
Effect Size				**0.55***			0.10*	0.11	**0.49***	**0.47***
Transition to Nanoscale Science (11 items)	4-6, 8, 14, 15, 21-22, 25, 29, 30, 38	5.9 (2.2)	7.4 (2.6)	1.5 (2.4)	5.7 (2.3)	5.7 (2.6)	0.0 (2.5)	0.2 (0.2)	1.7 (0.2)	1.5 (0.2)
Effect Size				**0.63***			0.00	0.09	**0.65***	**0.61***
Nanoscale Science (10 items)	16, 18, 19, 26-28, 31, 39, 40	3.4 (1.7)	5.1 (2.2)	1.7 (2.2)	3.1 (1.5)	3.5 (1.8)	0.4 (2.0)	0.3 (0.1)	1.7 (0.2)	1.4 (0.2)
Effect Size				**0.87***			0.24*	0.19*	**0.80***	**0.62***

Notes: * = statistical significance at p < .05.
Effect size = (mean treatment) – (mean control) / (average S.D. treatment and control).
Effect size less than 0.20 = little or no difference; 0.20 to 0.49 = small difference; 0.50 to 0.79 = moderate difference; 0.80 or higher = large difference.
Effect sizes of .25 or greater are considered "educationally significant" (Cohen, 1988).
Source: *NanoLeap* Chemistry Student Assessment, 2007-2008.

Table 2: Chemistry Student Assessment - Overall and By Science Content, 2007-2008 Field Test

		Treatment (n=365)			Control (n=290)			Difference Treatment - Control		
Mean (S.D.)	Items	Pre	Post	Gain Score	Pre	Post	Gain Score	Pre	Post	Gain Score
Total Score (40 items)	1-40	15.9 (4.2)	19.9 (7.3)	4.0 (5.9)	14.7 (4.4)	13.7 (4.6)	-1.0 (4.8)	1.3 (0.3)	6.3 (0.5)	5.0 (0.4)
Effect Size				**0.70***			-0.22*	**0.30***	**1.04***	**0.92***
Core Science (16 items)	2, 4, 6-12, 14-18, 23, 32	6.9 (2.4)	7.5 (2.9)	0.6 (2.5)	6.4 (2.5)	6.1 (2.5)	-0.3 (2.8)	0.5 (0.2)	1.4 (0.2)	0.9 (0.2)
Effect Size				0.23*			-0.12*	0.20*	**0.52***	**0.34***
Transition to Nanoscale Science (8 items)	5, 13, 19-22, 26, 31	2.8 (1.4)	4.0 (2.0)	1.2 (2.0)	2.7 (1.5)	2.4 (1.5)	-0.3 (1.8)	0.1 (0.1)	1.5 (0.1)	1.4 (0.2)
Effect Size				**0.71***			-0.20*	0.07	**0.86***	**0.74***
Nanoscale Science (16 items)	1, 3, 24. 25, 27-30, 33-40	6.2 (2.2)	8.5 (3.6)	2.2 (3.5)	5.5 (2.2)	5.1 (2.1)	-0.4 (2.4)	0.7 (0.2)	3.4 (0.2)	2.6 (0.2)
Effect Size				**0.76***			-0.19*	**0.32***	**1.19***	**0.88***

Notes: * = statistical significance at p < .05.
Effect size = (mean treatment) – (mean control) / (average S.D. treatment and control).
Effect size less than 0.20 = little or no difference; 0.20 to 0.49 = small difference; 0.50 to 0.79 = moderate difference; 0.80 or higher = large difference.
Effect sizes of .25 or greater are considered "educationally significant" (Cohen, 1988).
Source: *NanoLeap* Chemistry Student Assessment, 2007-2008.

Student Learning Findings

1. *Students in the physical science treatment group significantly outperformed their peers in the control group in terms of the gain in knowledge demonstrated from the pre- to the post-test.*
2. *Students in the chemistry treatment group significantly outperformed their peers in the control group in terms of the gain in knowledge demonstrated from the pre- to the post-test.*

Project Partners

McREL
An education research and development organization regarded as a pioneer in standards-based instruction

Stanford Nanofabrication Facility
A state of the art laboratory and vibrant community of academic, industrial, and governmental researchers from across the country and around the globe

NNIN *National Nanotechnology Infrastructure Network*

ASPEN Associates
A Social Policy and Evaluation Network

The NanoLeap team at SNF share their content expertise and offer an insider's view of the laboratory through remote access.

http://www.mcrel.org/nanoleap