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# The National Nanotechnology Infrastructure Network's Education and Outreach Programs – Helping student understand the tools of nanotechnology

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Nanoscale Science and Engineering (NSE) is a fast growing area of science and engineering that crosses all discipline boundaries. It has been stated that nanotechnology will impact every facet of our lives. The U.S. is a leader in developing education programs to meet NSE's workforce demands. [1] Workforce development programs are needed to excite students about possible education and career opportunities in STEM and nanotechnology to ensure that the U.S. maintains its competitive edge. The National Nanotechnology Infrastructure Network (NNIN) is an integrated geographically-diverse partnership of 14 university-based laboratories supported by the National Science Foundation. The primary focus of NNIN is to serve as state-of-the-art resource centers for researchers. The NNIN also has extensive education outreach programs for the K-gray population.

The purpose of this presentation will be twofold: 1. provide an overview of the NNIN's education and outreach programs including what has been successful in reaching students and teachers and 2. provide information on how we are teaching program participants about the tools of nanotechnology and size and scale (an important component of nanoscale science). Nanotechnology is science and engineering that occurs at the dimensions of 1-100 nanometers (in one dimension). At this scale, unique phenomena occur in materials which lead to researchers developing novel applications. At the nanoscale, materials may behave differently than the bulk counterpart. Nanotechnology involves "imaging, measuring, modeling, and manipulating matter at this length scale."[2]

A nanometer is one-billionth of a meter or $1x10^{-9}$m. The average human hair is approximately 50,000 to 70,000 nm in diameter. Nanoscale objects fall below the range of visible light so they cannot be seen with standard light microscopes. Students and teachers need to understand that a different set of tools are needed for visualizing nanoscale materials and devices. To help with this we introduce the concepts to size and scale and have outreach participants explore the tools of nanotechnology, in particular Scanning Electron Microscopes (SEM) and Atomic Force Microscopes (AFM). The concepts of size and scale are very important to understand when discussing nanotechnology because size defines the nanoscale and at the nanoscale the behavior of matter varies.

We have found that most students can provide the various SI units of measurement and may even define these prefixes. But where most students and teachers have difficulty, is understanding differences in size and scale as materials move from macro to micro to nano scales. We utilize a variety of activities to help develop an understanding of size and scale and how small objects in the nanoworld actually are. We employ two tools of nano, SEM and AFM, to allow program participants to actually explore the nanoworld. We use several approaches to help participants understand these concepts: participants explore materials with a variety of optical devices - magnifiers, handheld USB scopes, optical microscope – ending with SEM and/or AFM; create powers of ten with the SEM; and solve "mysteries" by examining some evidence that requires an SEM for analysis. All of these

activities are tied to two of the Big Ideas of Nanoscale Science: Tools and Instrumentation and Size and Scale. [3]. We have recently developed lessons for elementary grades to help lay the foundation for more advanced work with size and scale and tools in middle and high school grades. These lessons are based on literature and allow children to explore the size of objects, magnification, and tools. We also use the SEM and AFM in general outreach programs such as school group visits (on and off site); public events such as NanoDays; and an imaging contest held at the National Science Teachers Association in collaboration with Hitachi HTA.

Our programs are designed to help individuals explore the nanoworld through hands-on activities. Through these activities, we hope that individuals will develop an understanding of the concepts of size and scale and the tools needed to explore and manipulate the nanoworld. We believe such exploration is important to eventually understanding nanoscale phenomena.

References

[1] Murday, J.S., Chair. *International Benchmark Workshop on K-12 Nanoscale Science and Engineering Education*, National Science Foundation Workshop Report 2010. Accessed at: http://www.nsf.gov/crssprgm/nano/reports/Educ11_NSEE+Benchmarking+K-12+NSE+Education_117p_May+2011.pdf
[2] National Nanotechnology Initiative, *What is Nanotechnology?* accessed at: http://www.nano.gov/html/facts/whatIsNano.html
[3] S.Y. Stevens, L.M. Sutherland, and J.S. Krajcik, *The Big Ideas of Nanoscale Science and Engineering: A Guidebook for Secondary Teachers*, NSTA Press, Arlington, VA. Pp. 203, 2009.


Figure 1 a & b. Teachers using the Hitachi TM3000 to create images for the "Image of the Day" contest at the NNIN booth at NSTA.

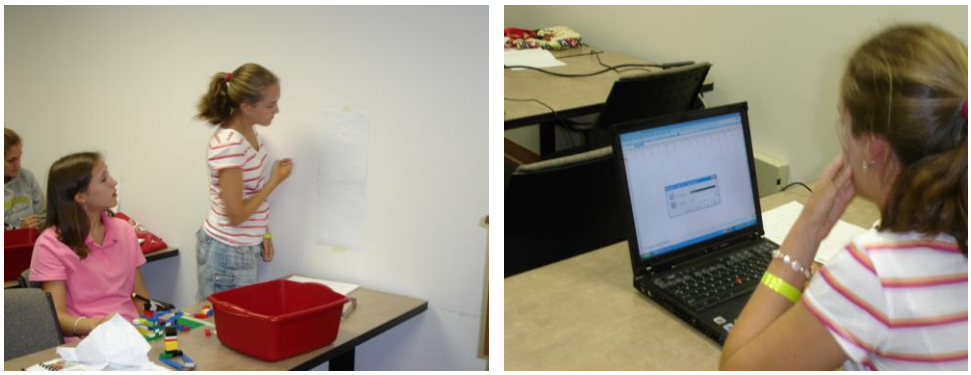

Figure 2 a & b. Students testing a model AFM and plotting data before using Nanoscience Instrument's the Nanosurf® EasyScan 2 AFM.

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