

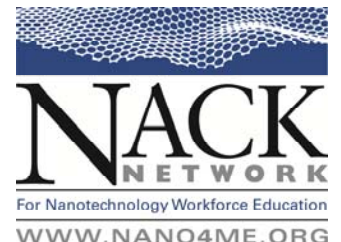


A University-Community College Partnership Model for Meaningful Advanced Manufacturing Workforce Education

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Utilization & the NSF National Nanotechnology Applications
and Career Knowledge (NACK) Network





Presentation Outline

- 1) **Historical**
- 2) *CNEU/NACK Approach*
- 3) *Resource Sharing and the Pennsylvania Nanofabrication Manufacturing Technology Partnership*
- 4) *NACK Partnership and How it Works*
- 5) *What the Community Colleges Find Helpful*
- 6) *What the Community Colleges Utilize*
- 7) *Advantages to Research University in Partnering with Local Community Colleges, Colleges, and Small Universities*
- 8) *How to Implement Model for Other Advanced Manufacturing Fields*
- 9) *Conclusion*



Historical

- Penn State's Center for Nanotechnology Education and Utilization (**CNEU**) established in **1998**. Focused on education across all aspects of micro- and nanofabrication
- With PA state support **PA Nanofabrication Manufacturing Technology (PA NMT) Partnership** for nanofabrication workforce development established at CNEU in **1998**
- **National Science Foundation (NSF) Advanced Technology Education (ATE) Regional Center** for nanotechnology workforce development at CNEU from **2001 to 2008** (National role since 2005)
- **NSF ATE National Nanotechnology Applications and Career Knowledge (**NACK**) Center** created at CNEU in **2008** and funded through **2012**
- Renewed by the NSF as **NACK Network** for **2012 through 2015**





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CNEU/NACK Approach

1. *Build partnerships in nanofabrication manufacturing education among Research Universities, 2-year Community and Technical Colleges, and 4-year Colleges/Universities through:*
 - *Resource sharing (courses, laboratory facilities, staff, programs)*
 - *Creating education pathways through these institutions for student development*
2. *Develop the means to enable a broad nanofabrication manufacturing education in synthesis, processing, characterization, and applications at 2-year Community and Technical Colleges in every region of the US*
3. *Educate students for careers in a spectrum of industries by advocating a knowledge base which can be used in many types of applications and companies*
4. *Insure that this broad nanofabrication and manufacturing education is one which students can build upon throughout their professional careers*



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What is the PA NMT Partnership?



***PA Associate &
Baccalaureate Students***



***“Hands-On” Capstone
Semester @ PSU***



***Grads to PA Industry
/ Academia***

***Capstone Semester = 18 credit hands-on immersion experience offered
at Penn State for all PA partner schools***

What is the PA NMT?

*Suite of
Hands-On
Courses in
processing,
process
control,
characterization,
& applications*

Available to PA
College and
University
Partners

- *A one-semester hands-on immersion in nanofabrication technology.*
- *Courses taught at the sophomore level-ideal for permitting one suite of courses for community college students, 4-year university students, and incumbent technicians.*
- *Classroom and laboratory components taught at Penn State.*

Resource Sharing: the Example of the Suite of Six Nanofabrication Manufacturing Courses

CNEU created and provides a suite of six 4th semester (sophomore) level nanofabrication manufacturing courses

The Courses

[E SC 211](#) *Material, Safety and Equipment Overview for Nanotechnology*

[E SC 212](#) *Basic Nanotechnology Processes*

[E SC 213](#) *Materials in Nanotechnology*

[E SC 214](#) *Patterning for Nanotechnology*

[E SC 215](#) *Nanotechnology Applications*

[E SC 216](#) *Characterization, Testing of Nanotechnology Structures and Materials*

Skills Necessary for the Courses

- *Basic properties of matter: atoms, molecules, gases, liquids, solids*
- *Basic concepts of chemistry*
- *Basic concepts of electro-magnetic phenomena*
- *Basic concepts of electrostatics*
- *Interaction of energy and matter*
- *Physics of light*
- *Introduction to biology (Optional)*

Skill set developed in the courses

Basic Nanotechnology EHS Awareness

- Basics of Chemical and Material Properties—Role of Scale
- Chemical and Materials Handling, Storage, and Disposal
- Nanotechnology Health, Safety, and Environmental issues

Nanotechnology Equipment and Processing Foundation Skills

- Chemical Hoods and Glove Boxes: Use and Maintenance
- Cleanrooms: Use and Maintenance
- Pumps, Flow Control Systems, Scrubbers, Sensors: Use and Maintenance
- Vacuum Systems: Use and Maintenance
- Plasma Generating Systems: Use and Maintenance
- Furnaces, Ovens, and Rapid Thermal Annealing Equipment: Use and Maintenance
- Chemical Facilities and Maintenance
- Contamination Control
- Process Integration
- Introduction to Statistical Process Control

Nanotechnology Patterning

- Optical, e-beam, and Ion Beam Lithography
- Stamping and Imprinting Lithography
- Chemical techniques; e.g., Block co-polymers and SAMs

Nanotechnology Fabrication

- Top-down Fabrication
 - Reactive Ion, Sputter, and Wet Etching
 - Chemical Vapor and Physical Vapor Deposition Systems
 - Ion Beam, Plasma, and Chemical Materials Modification
 - Nanoparticles: Etching and Grinding Approaches
- Bottom-up Fabrication
 - Chemical, Physical, and Biological Self-Assembly
 - Nanoparticles: Colloidal Chemistry
 - Nanoparticles: Plasma Approaches
 - Nanoparticles: Chemical Vapor Deposition Approaches

Nanotechnology Characterization

- Optical Microscopy
- Scanning Probe Microscopy
 - Atomic Force Microscopy
- Electron Microscopy
 - Scanning Electron Microscopy (SEM and FE-SEM)
 - Transmission Electron Microscopy (TEM and FE-TEM)
- Chemical Characterization
 - X-ray (EDS)
 - Secondary Ion Mass Spectroscopy
 - Auger Electron Spectroscopy
 - Fourier Transform Infrared Spectroscopy
- Electrical Characterization
 - Current-Voltage Measurements
 - Capacitance Measurements
 - Opto-electronic Device Measurements
- Physical Characterization
 - Spectrophotometer
 - Profilometer
 - X-ray Diffraction

Nanotechnology Professional Skills

- Team Building
- Problem Solving
- Project Organization and Planning
- Research Skills
- Assessing Cost of Ownership
- Presentation Skills
- Technical Reporting and Documentation
- Handling and Generating Intellectual Property

Central Facility “Physical Offering”: The PA NMT Example

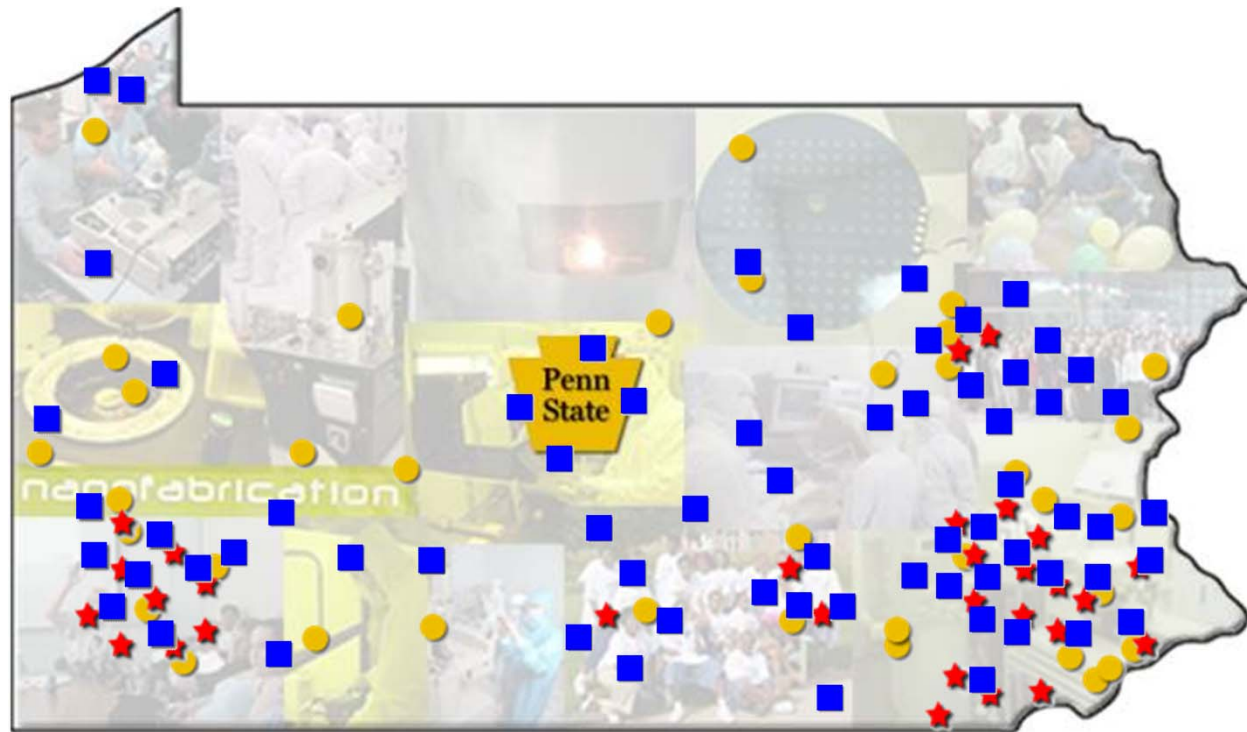
- *This suite of six courses is taught twice/year – as a service by Penn State – for PA 2-year and 4-year degree-granting institutions*
- **PA NMT is supported by funds provided by the State of Pennsylvania**
- *Central Facility Approach—i.e., facility for a region. However credits come from “home” school*
- *Taken to-date at University Park by 774 students from community colleges, colleges, and universities.*
 - **95%** *of those graduates think that it was a valuable education and 90% said it influenced their educational pathways.*
 - **60%** *of survey respondents in the pool of graduates are continuing for a 4-year or graduate degree.*
- **Advantages**
 - *Resource sharing (Equipment and staff needed to support equipment only at one place)*
 - *Expensive equipment dedicated - only needed at one location*
 - *Staff available at research university with awareness of, and giving attention to, health, safety, and environment issues*

Resource Sharing between Research Universities and Community and Technical Colleges for Facility and Equipment Hands-On Experience

- *Hands-on components taught at research university, community college, industry, and national lab hub sites (where there is equipment and resources to support it).*
- *In PA NMT: The 6 Nanotechnology Courses in Pennsylvania are taught for PA post-secondary institutions (more than 30) using the teaching cleanroom and PSU NNIN facilities at University Park*
- *In PA NMT: The students spend 3 hours per day in **lecture** and 3 hours per day doing **labs in cleanroom***
- *The goal is hands-on total immersion in nanofabrication and characterization*

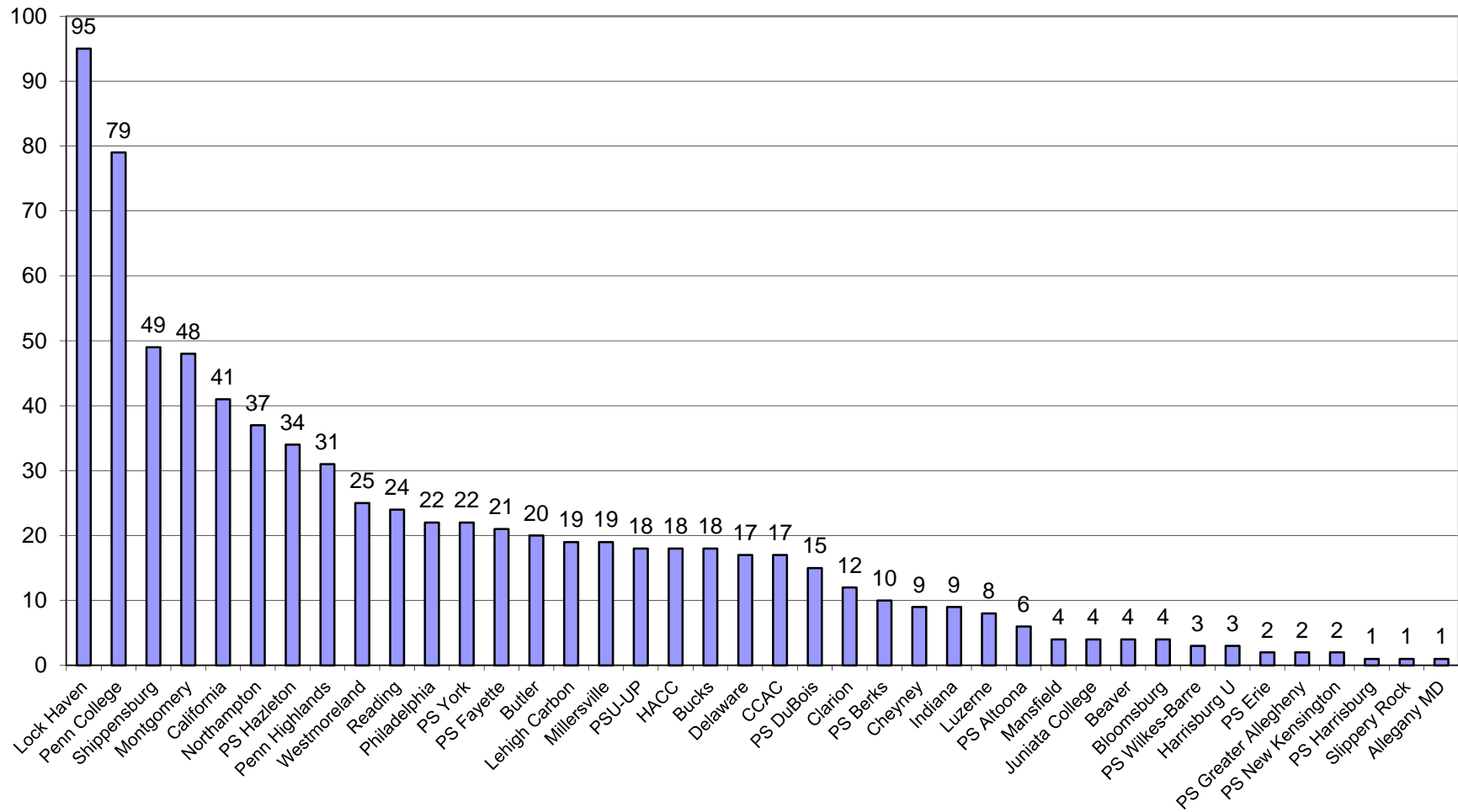


Participating Institutions in the PA Central Offering Approach



- Academic Partners
- ★ Industry Advisory Board Members
- PA Companies who have hired NMT graduates

**NMT Capstone Semester Completers
(Fall 1998 - Summer 2013)
Total = 774**

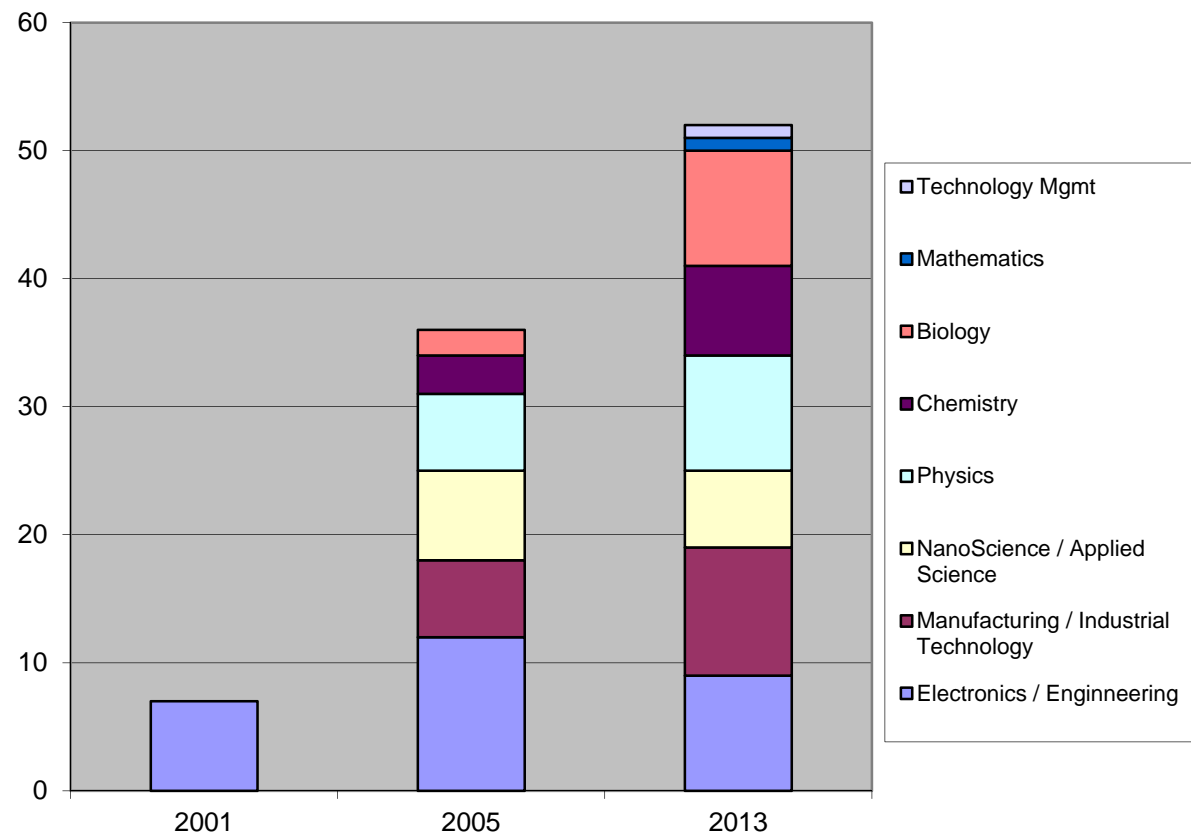


NMT Partners

Diversity & Growth of Disciplines Housing Degree Programs in Nanotechnology: The PA Experience

Taking the six courses in nanotechnology results in:

1. *Nanotechnology Concentration, or Nanotechnology Minor within a Major degree*
2. *New degrees e. g., Associate Degree in Nano-Chemical Technology*

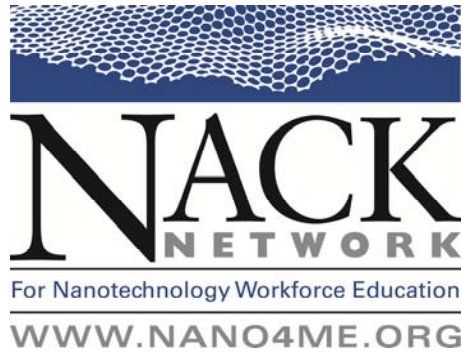




Presentation Outline

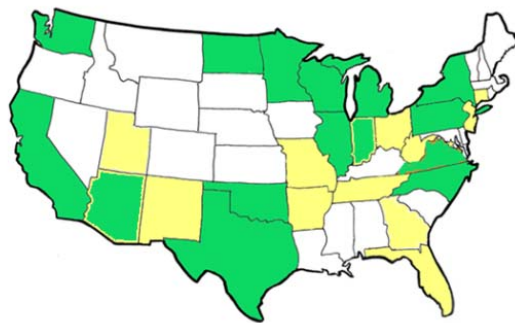
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What is NACK?

The Mission of NACK is to enable Nanofabrication Manufacturing Education at:



- 2-year Community & Technical Colleges in every region of the U. S.
- 4-year Universities and Colleges in Partnership with Community & Technical Colleges in every region of the U. S.

Building Partnerships: NACK Network Hubs



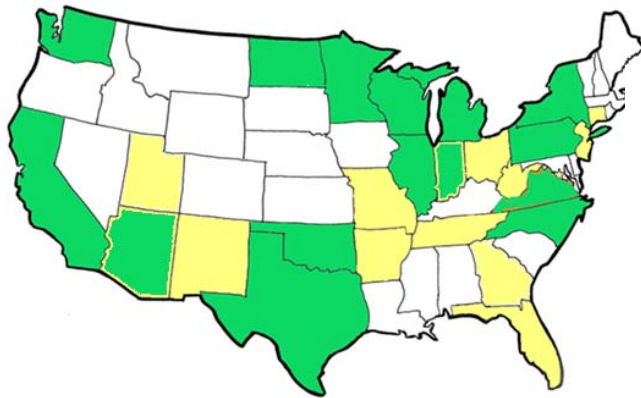
*NACK - ATE Center in PA
PA Community Colleges
Penn State University (PA
NMT)*



*Dakota County
Technical College
University of
Minnesota*



*University of
Puerto Rico,
Humacao*



*Ivy Tech Community
College
University of Notre Dame*



*NEATEC - ATE
Center in NY
University at
Albany (SUNY)*



*Northwest Vista
College
University of
Texas*



*North Seattle
Community College
University of
Washington*



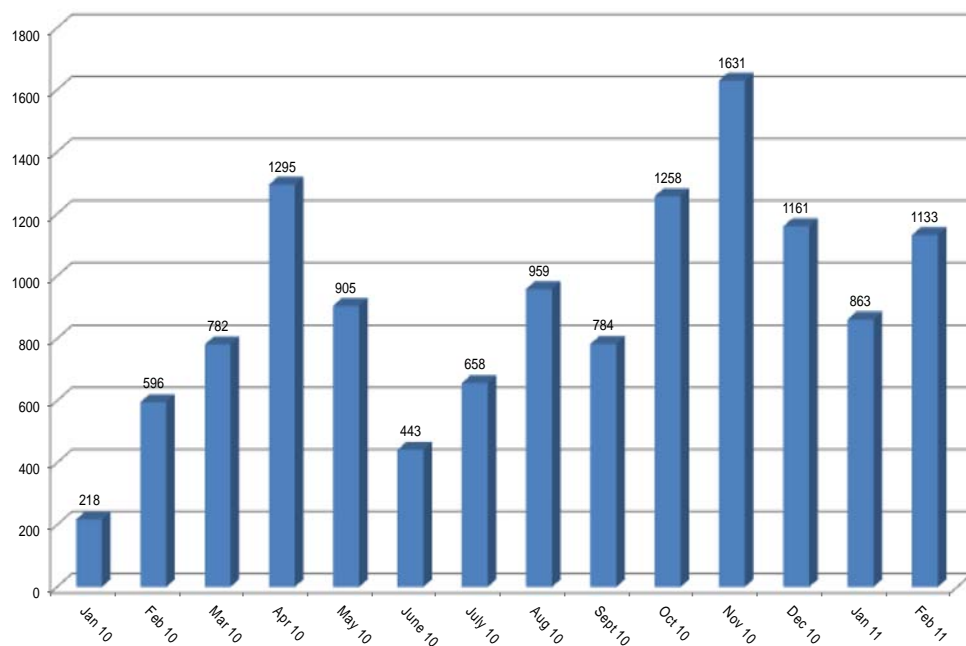
*Central Arizona Community
College
Maricopa Community
Colleges
Arizona State University
MATEC - ATE Center in AZ*



Nano4me.org Web Site

The Portal to NACK Resources

Nano4me Resource Downloads



Nano4Me.org Brought to you by the Nanotechnology Applications and Career Knowledge Center (NACK)

HOME STUDENTS ALUMNI EDUCATORS INDUSTRY ABOUT US PARTNERS

Webinars
 Remote Access - Integrating High Tech Tools Into Your Classroom
 September 28, 2012
 Societal and Ethical Issues in Nanotechnology Part II
 November 2, 2012

Workshops
 Nanotechnology Course Resources I: Safety, Processing, and Materials
 September 17-20, 2012
 Nanotechnology Course Resources II: Patterning, Characterization, and Applications
 October 1-4, 2012

Students
 Find a Nano Program
 Find or Post a Job [Click Here](#)
 Connect With Alumni
 Facebook LinkedIn

Alumni and Industry
 Penn State Awarded 3-year grant from the National Science Foundation
 White House report highlights Penn State Nano Program
 Read More

In the News
 Dr. Stephen J. Fonash
 Director, Penn State Center for Nanotechnology Education & Utilization.
 Read More

Educator Resources
 Find FREE Resources for Your High School & Undergraduate Classroom
 Sign Up Browse Login

Remote Access
 Connect Remotely and bring cutting-edge technology to your classroom!
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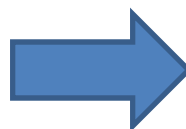
About Us
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Partners
 IVY Tech
 MATEC
 Nano-Link
 NATEC
 NW Vista
 SHINE
 UPR

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Undergraduate Level Course Material for 6 NACK Courses

- Classroom component lectures available on the web as PowerPoint presentations and as videos.
- Lab components also available as videos for students limited by travel distances to hubs.



The screenshot shows the Nano4Me.org website. The top navigation bar includes links for 'K-12 Resources' and 'Post-Secondary Resources'. The main content area is titled 'Undergraduate Level Course - Classroom Presentations'. It includes a note about registration and a list of resources for ESC 211: Materials, Safety, & Equipment Overview for Nanotechnology. The resources are categorized into PDF Files, PowerPoint Files, and Videotaped Lectures.

Undergraduate Level Classroom Presentation Materials

ESC 211: Materials, Safety, and Equipment Overview for Nanotechnology

Unit Title	PDF File	PowerPoint File	Videotaped Lectures		
1. Safety and Environmental Concerns	Download	Download	Lecture 1	Lecture 2	
2. Vacuum Function, Operation and Systems	Download	Download	Lecture 1	Lecture 2	
3. Materials Overview	Download	Download	Lecture 1	Lecture 2	Lecture 3
			Lecture 4	Lecture 5	Lecture 6
4. General Processing Concerns, Contamination, and Damage	Download	Download	Lecture		
5. Basic Characterization Tools	Download	Download	Lecture 1	Lecture 2	

ESC 211 Laboratories

ESC 211 Lab Overview

Lab 1: EHS: Chemical & Materials Overview

Lab 2: EHS: Equipment Safety Awareness

Lab 3: Vacuum Equipment Simulation Lab with EquipSim

Lab 4: Vacuum Equipment Components & Systems Part 1

Lab 5: Vacuum Equipment Components & Systems Part 2

Lab 6: Introduction to Metrology & Characterization

Some Job Titles Held by Nanofabrication Manufacturing 2-Year Degree Graduates

✓ *Biological Laboratory Tech.*

Biofuels Tech.

✓ *Chemical Laboratory Tech.*

Cleanroom Tech.

Deposition Tech.

Device Tech.

✓ *Equipment Maintenance Tech.*

Engineering Tech.

Etch Tech.

Failure Analysis Tech.

Laboratory Tech.

✓ *Lithography Tech.*

Materials Science Lab Tech.

✓ *Medical Devices Tech.*

Microfabrication Tech.

Nanobiotech Researcher

✓ *Nanoelectronics Expert*

Nanofabrication Tech.

Nanotechnologist

Process Tech.

Production Scientist

✓ *Quality Control Tech.*

✓ *Research Assistant*

✓ *SEM Operator*

SPM Operator

Scientist Specialist

Solid State Tech.

Test Tech.

Thin Films Tech.

✓ *Vacuum Tech.*

Employment Statistics/Metrics

- *The total number of companies employing graduates from NACK hubs is approximately **200 (141 from PA NMT)**.*
- *Number of survey respondents, in the pool of graduates, who are employed in nano-related field is **69%**.*
- ***100%** of the industry respondents expressed very positive feedback on the 6 NACK core-skills courses.*
- ***75%** of industry respondents recommended NACK work with a professional society for a national accreditation for the NACK core-skills set.*
- *Associate degree graduates who had taken the immersion semester had an average salary of **\$37,000**.*
- *BS degree graduates who had taken the immersion semester had an average salary of **\$56,000***

Institutions That Have Hired Capstone Semester Graduates for Micro- and Nanofabrication Manufacturing Jobs

II-VI Corporation
Accellent
Adhesives Research, Inc
Advanced Acoustic Concepts
Advanced Cooling Technologies
Advanced Gas Technologies
Advanced Powder Products
Advantech
AGAM
Agere
Alcoa
Allied Electronics
Alden Products
AMAX Minerals
Amedeo
Amgen Inc.
Apogee Photonics
Arrow International
Avail Technologies
BioElectroSpec
B. Braun
Boston Applied Technologies
BD (Becton, Dickinson)
BP Solar
Bridge Semiconductor
Busch Vacuum
Cabot
Cabot Microelectronics
Carbon NanoProbes
Celgene-LifebankUSA
Chemcut
Correge Sensors
Cosmos Technologies
Crystalplex
Cyoptics
Dendreon
DRS Laurel Technologies
Dana Corporation
Doucette
Don's Salads
Dow Chemical
Drexel University
Eastman Chemical Company
East Penn Manufacturing
Ex One
Fairchild Semiconductor
Fincor Automation

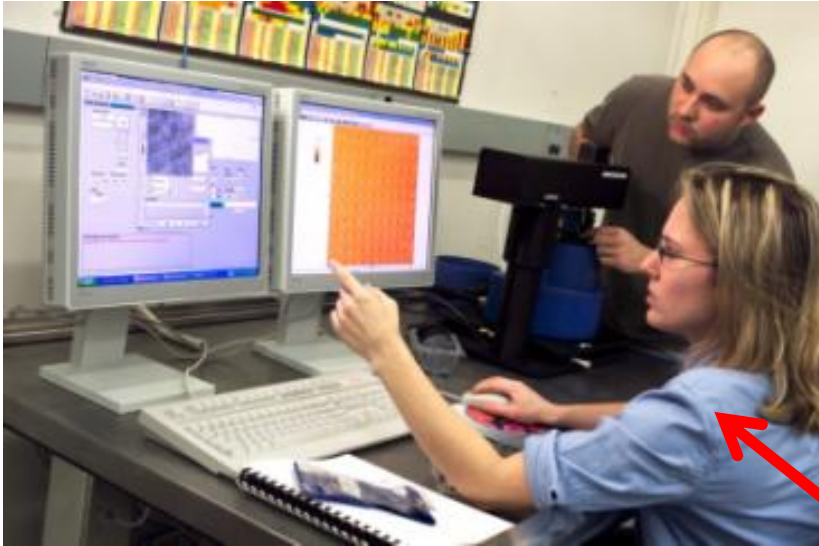
First Energy
F.S. Elliott
General Dynamics Robotic System
General Electric
Glass automatic
GlaxoSmithKline
Globalfoundries
GTS
Haraeus Noblelight
Hale Products
Hershey Medical Center
Illuminex
Infinera
Inovative Micro Technology
Intel Corporation
iNOEX
IQE
Johnson & Johnson
Johnson Matthey
Judson Technologies
Keystone Communications
Keystone Engineering
Keystone Research & Pharmaceuticals
Kongsberg Defense
Kurt J. Lesker
Kyowa America
LCM Technologies
Leighton Electronics
Lockheed Martin
Lucent Technologies
Lutron Electronics
Maxima Technologies
Max Levy Autograph
Meadow Burke Products
Membrane Assays
Merck
Mintera Corporation
NanoHorizons
Natural Nano, Inc
North American Hoganas
North Carolina State University
Northrup Grumman, Inc
Optellios
Optinel Systems
P2i
Penn State CNEU

Penn State Dubois
Penn State Applied Research Lab
Penn State Electro-Optics Center
Pfister Energy
Philips Medical Systems
Philips Respiration
Plextronics
Probes Unlimited
Proconex
PPG
PPL
QorTek
Restek
Rheteck
Rohm and Haas
Ross Technologies
RJ Lee
Schroeder Industries
Scientific Systems
Seagate Technologies
Siemens Co.
SI International
Slack Pek
Solar Innovations
Solarity
Spectrum Technologies
Strainrite
Strategic Polymers
Structure Probes Inc.
Synthes
Telecardia
Textron Lycoming
Thermo Electric PA
Transene
Tyco Electronics
US Air Force
Uniroyal Optoelectronics
University of Florida
University of North Carolina - Charlotte
University of Pittsburgh
Vectron International
Velox Semiconductor
Western Digital
Westfalia Technologies
Westmoreland Mech. Testing & Research
Xactix

National Advisory Council

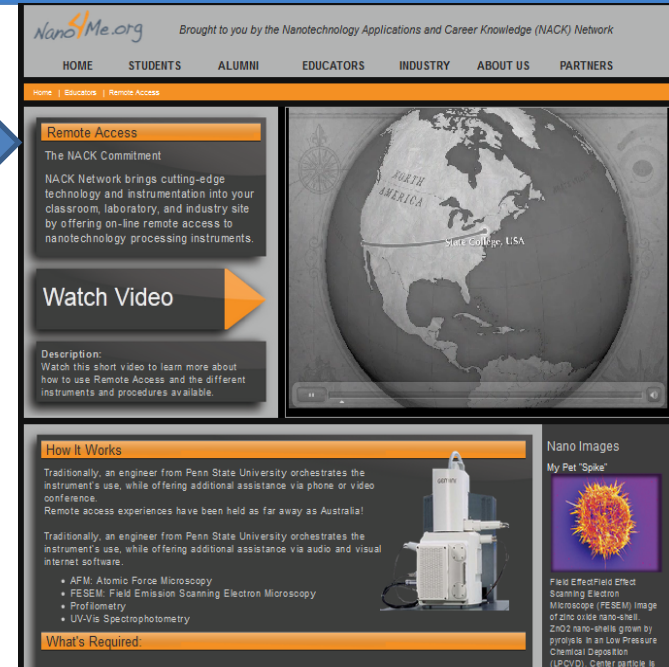
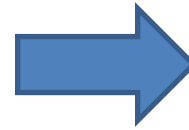
- *Alcatel-Lucent*
- *Bio-Link Center*
- *Boeing*
- *Corning*
- *Cyoptics*
- *Dupont*
- *General Electric*
- *Imerys*
- *Information & Communications Technology Center*
- *Johnson & Johnson*
- *Lockheed Martin*
- *3M*
- *National Council for Advanced Manufacturing*
- *National Coalition for Advanced Technology Centers*
- *Northrop Grumman*
- *PPG*
- *Plextronics*
- *Semiconductor Research Corporation*
- *Strategic Polymers*
- *Stryker*
- *Tyco*
- *University of Minnesota*

Remote Access & Control of Nano Equipment



From our lab...

- *Established web access procedures for nanocharacterization, e. g. FESEM*
- *Established low-cost methodology for web access and control*



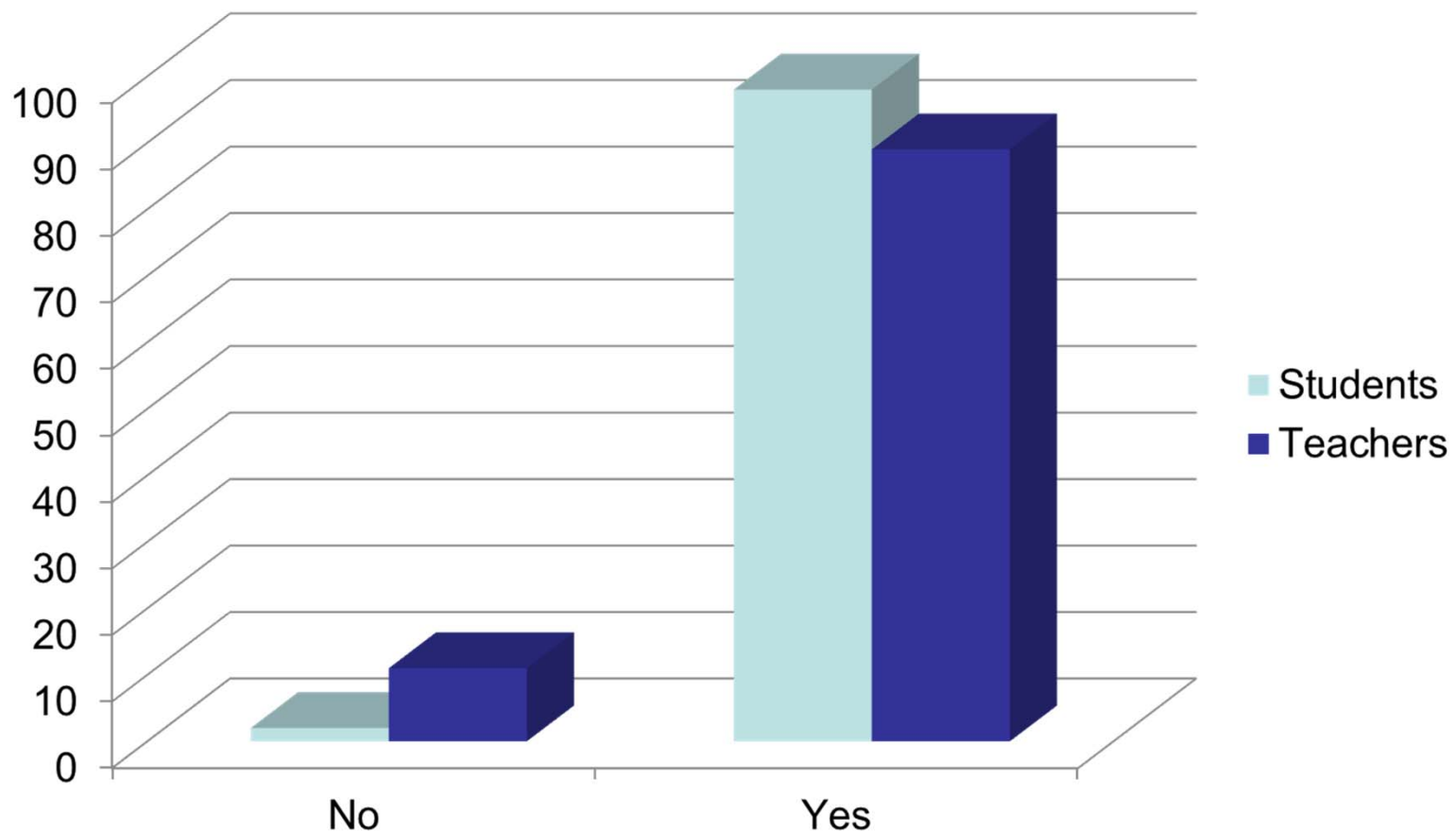
...to any classroom

Remote Access can be utilized

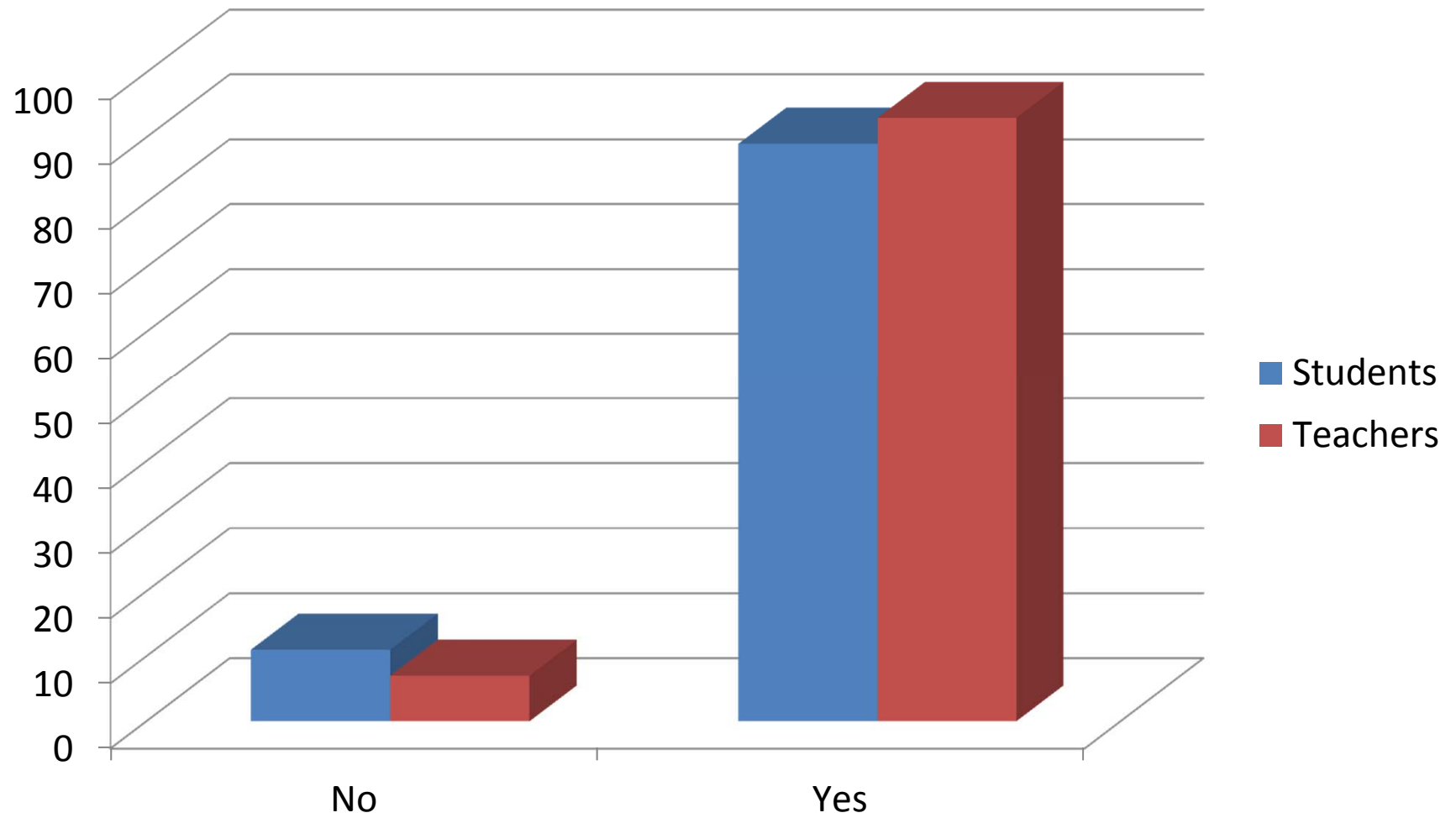
- *For an outreach experience*
- *For workshop demonstrations*
- *For class demonstrations*
- *To supplement the equipment at an institution*
- *For “Hands-On” access by students in laboratory experiences*

RESULTS FROM MORE THAN 600 PARTICIPANTS

Would you recommend remote access to another teacher/classmate , faculty member/colleague?

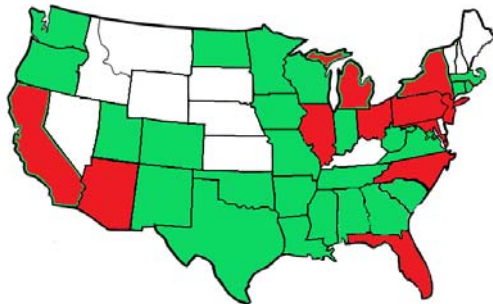


Did you find remote access more valuable than traditional text-book and/or lecture-based learning?



Faculty development: Educator Workshops

- Hands-on Introductory Workshop for Educators
- Nanotechnology Course Resource Workshops on “how to implement and teach courses”
- *Attendees to Date*
 - **1115** Educators
 - **36** States, DC, and Puerto Rico



Attendance Options :

- *Attending a workshop at NACK*
- *Host an on-site/off-site workshop*
- *Utilizing NACK workshop material and/or remote lecture and/or remote equipment access at local workshops*

NACK Services to Secondary and Post Secondary Institutions

Modules Downloadable at
www.nano4me.org



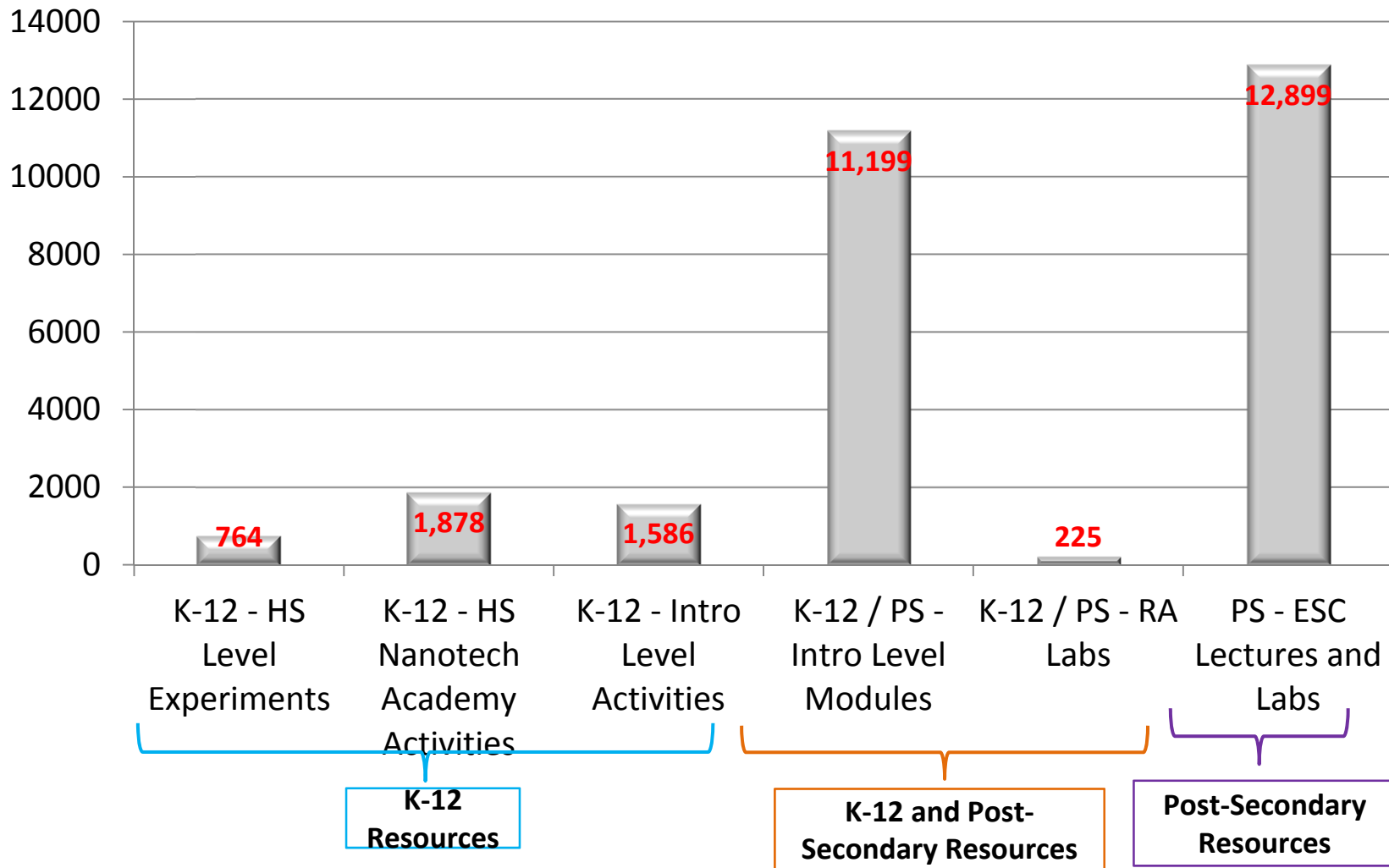
Nanotech Academies



Secondary School
Curriculum Enhancement

- *Series of thought-provoking nanotechnology presentations*
 - *in-depth material for students and workers of all knowledge levels.*
- *Designed to be used in workshops, courses, and overview lectures*
 - *introduce nanotechnology and its applications.*
- *Can be integrated into secondary and post-secondary curriculum as well as for nanotechnology outreach*
- *Assistance to over **301** post-secondary institutions in their nanotechnology education efforts.*
- ***1,148** Secondary school students have completed Nanotech Camps.*

NACK Portal Downloads by Audience
January 2009 - March 2013
Total Downloads: 28,551



NACK Network Webinars



The screenshot displays the Nano4Me.org website. The header includes the logo and navigation links: HOME, STUDENTS, ALUMNI, EDUCATORS, INDUSTRY, ABOUT US, PARTNERS. A blue arrow points to the 'NACK Network Webinars' link in the left sidebar. The main content area features 'Webinar Fast Facts' and a list of past webinars on the right.

NACK Network Webinars

The NACK Commitment

The NACK Network offers a live webinar, hosted by MATEC NetWorks, every month to engage and educate those of you that are interested in learning more about nanotechnology related topics.

Webinar Fast Facts:

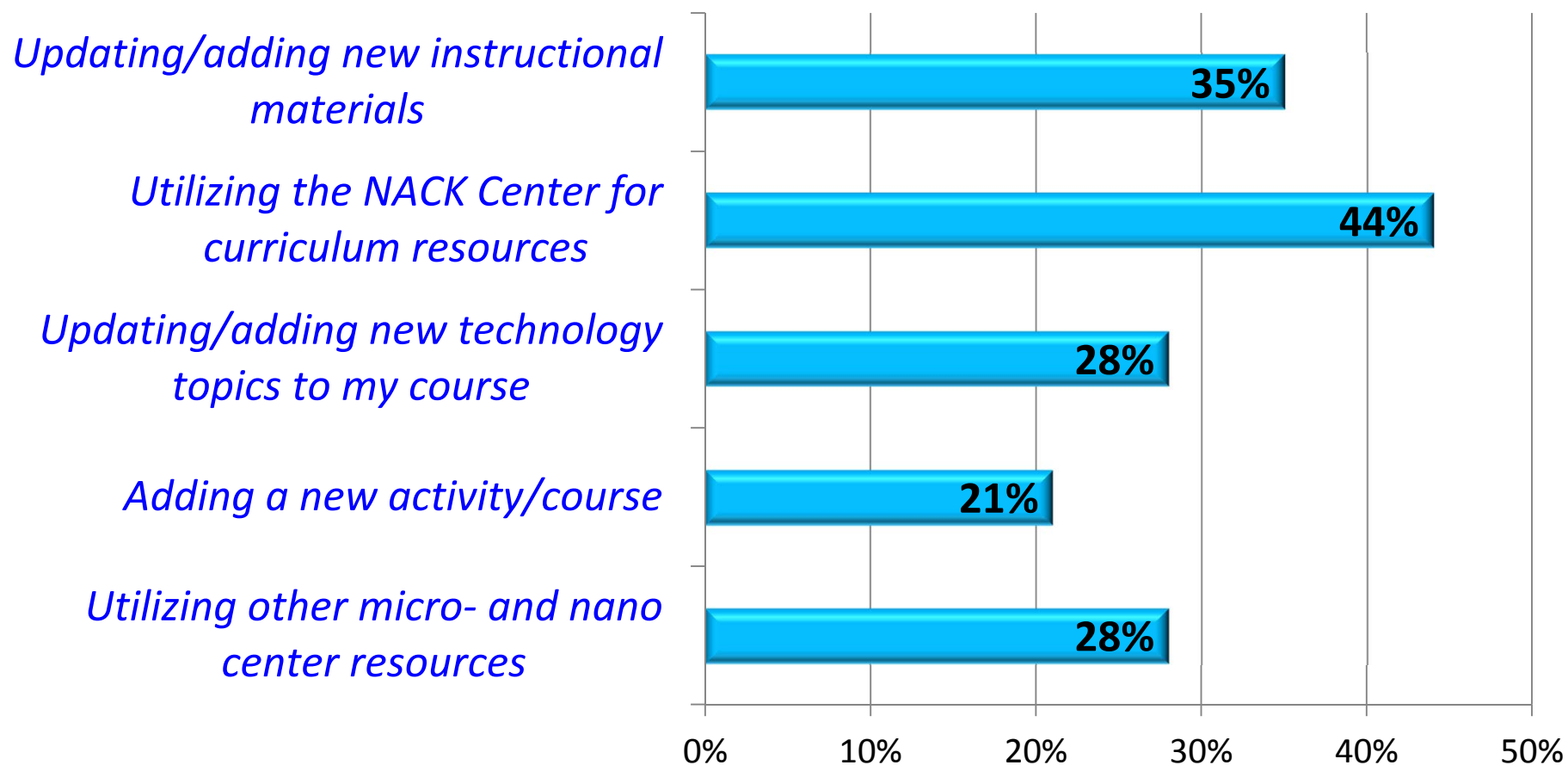
- 1 - 2:30 pm E.T.
- Led by content experts
- Free to attend
- Certificate of Attendance on request for professional development credit
- Archives made available within 3 business days
- Great for faculty, students, administrators and industry!

2012 - 2013 Webinars

- (Three part series) Trends in Nano: Careers and Workforce Needs - May 16, 2013
 - Webinar
 - Slides
 - Handout
- The National Nano Alumni Network Presents: LinkedIn Profile Essentials: Building Your Professional Network - May 9, 2013
 - Webinar
 - Slides
- Successful Models for Nano Outreach - April 25, 2013
 - Webinar
 - Slides
 - Handout
- (Three part series) Trends in Nano: Program Development - March 22, 2013
 - Webinar
 - Slides
 - Handout
- Nanotechnology Demos and Simulations - February 22, 2013
 - Webinar
 - Slides
 - Handout
- (Three part series) Trends in Nanoelectronics: Microchips and More - January 25, 2013
 - Webinar
 - Slides
 - Handout
- Societal Dimensions of Responsible Innovation for Nanotechnology - December 14, 2012
 - Webinar
 - Slides
 - Handout
- Remote Access - Integrating High Tech Tools Into Your Classroom - September 28, 2012
 - Webinar
 - Slides
 - Handout

- *Live monthly 90 minute webinars hosted by MATEC*
- *To engage and educate about nanotechnology related topics*
- *Archived at www.nano4me.org for convenient viewing*
- *Why Webinars?*
 - **92% Agree** – they are valuable
 - **87% Agree** – they will impact my students, colleagues and me
- *Who has actually done anything with the content?*
 - Up to **28%** updated materials in their classrooms
- *To date **3,254** individuals have accessed these webinars.*
- ***132** community and technical colleges have used NACK workshops and webinars.*

Anticipated impact on teaching and technology programs as a result of attending a 2012-2013 NACK Webinar



NACK Alumni Network



•To help graduates of associate degree programs enhance their professional opportunities, inform them of educational opportunities, and connect them with networking groups.

✓ Provides online networking opportunities.

✓ Accesses career resources.

✓ Connects interested alumni and students in mentoring relationships.

✓ Keeps alumni informed of current nanotechnology events and activities.

✓ Shares alumni success stories.

•14,379 hits on NACK Alumni network website .

Additional Miscellaneous CNEU/NACK's Products and Services

- *Penn State's College of Engineering undergraduate manufacturing technology certificate.*
- *Working on a graduate level distance learning M.S. degree.*
- *Standard drafts for use by the American Society for Testing and Materials (ASTM) to develop the NACK industry core-skill set into ASTM standards.*
- *Participation in the Nanoscale Informal Science Education Network (NISE Net) Nano-Days activities for student recruitment and parent education (over **500** students and parents impacted to date with these NACK activities).*
- *Initiated Nanotechnology Career Days activities for nanotechnology companies to recruit trained students.*

Additional Miscellaneous CNEU/NACK's Products and Services (contd.)

- *Initiated an e-mail service advertisements and structure for companies to post job openings through local nanofabrication manufacturing education programs.*
- *Sharing the NACK mission and experience through presentations and table displays at **38** education conferences held in the U. S.*
- *Initiation of the Annual Micro/Nanotech (MNT) Conference: this conference is a national educators meeting hosted by NACK and the four NSF regional micro/nanotechnology ATE centers.*
- *Distant Education nanofabrication manufacturing certificate will be offered soon through NACK and will be integrated into community college programs.*

Summary of CNEU/NACK Resources

*Six Nanofabrication
Manufacturing
Courses*

*Student
Recruitment*

*Educators
Workshops*

*Remote
Access
Tools*

*Nanotech
Academies*

*Industry
Outreach*

*2+2 and 2+2+2
Education
Pathways*

*Secondary School
Curriculum
Enhancement*

*Incumbent
Worker Training*

*Nano4me.org
Web site*

*Teaching
Cleanroom*

*Alumni
Services*

Recent National Recognition of NACK

REPORT TO THE PRESIDENT AND CONGRESS ON THE FOURTH ASSESSMENT
OF THE NATIONAL NANOTECHNOLOGY INITIATIVE

Workforce Development

With the support of the NSF's Advanced Technology Education (ATE) program, Penn State has developed a nation-wide partnership of research universities and community colleges that is bringing meaningful core-skills nanotechnology workforce education to technical and community colleges across the United States. This partnership, the NSF



National Nanotechnology Applications and Career Knowledge (NACK) Network, fosters (1) resource sharing among community colleges and research universities for nanotechnology workforce development, (2) the availability of course materials, for web or in-class use, covering a core-set of industry-recommended nanotechnology skills and (3) broad student preparation for careers in the wide spectrum of industries utilizing micro- or nanotechnology. NACK has created and offers continually updated, free-of-charge core-skills course lecture and lab materials, web-accessible equipment capability, and faculty development workshop curricula. Since the inception of the nationwide effort in 2008, NACK research university-community college partnership hubs have been set-up and are functioning in Puerto Rico, New York, Indiana, Minnesota, Texas, and Washington State. Others are underway and these are in addition to the hub comprised of 30 Pennsylvania schools and funded by the State of Pennsylvania since 1998. To-date, there have been over 800 graduates from the nanotechnology core-skill classes offered by the NACK hubs, 20,881 web downloads of NACK educational materials, and 957 educators who have completed professional development workshops. The Penn State nanotechnology workforce development programs began as a Pennsylvania-focused activity with the founding of Pennsylvania Nanofabrication Manufacturing Technology (NMT) Partnership funded by the State in 1998. In 2003 the additional component of an NSF ATE regional center for nanotechnology workforce education was added. In 2008 this NSF ATE activity evolved into the NACK Network nationwide workforce development partnership. By creating education pathways from high school to skilled manufacturing careers across the country, the NACK Network is working to train the U.S. nanotechnology manufacturing workforce.

REPORT TO THE PRESIDENT
AND CONGRESS ON
THE FOURTH ASSESSMENT
OF THE NATIONAL
NANOTECHNOLOGY INITIATIVE

Executive Office of the President
President's Council of Advisors on
Science and Technology

APRIL 2012



“With the support of the NSF ATE program, Penn State has developed a nation-wide partnership of research universities and community colleges that is bringing meaningful core-skills nanotechnology workforce education to technical and community colleges across the United States.....”

http://www.whitehouse.gov/sites/default/files/microsites/ostp/PCAST_2012_Nanotechnology_FINAL.pdf



Presentation Outline

- 1) *Historical*
- 2) *CNEU/NACK Approach*
- 3) *Resource Sharing and the Pennsylvania Nanofabrication Manufacturing Technology Partnership*
- 4) *NACK Partnership and How it Works*
- 5) **What the Community Colleges Find Helpful**
- 6) *What the Community Colleges Utilize*
- 7) *Advantages to Research University in Partnering with Local Community Colleges, Colleges, and Small Universities*
- 8) *How to Implement Model for Other Advanced Manufacturing Fields*
- 9) *Conclusion*



- *NACK helps facilitate the development of university and community college partnerships*
- *Not necessary to create new nano courses*
- *Course materials kept up-to-date by research university partners*
- *No need to invest in expensive equipment*
- *Staff for equipment support is not needed*
- *Able to offer nano program attractive to multiple disciplines*
- *Can create pathways for student articulation*
- *NACK is working with Historically Black Colleges and Universities (HBCU) to build collaborations in nanotechnology education.*
- *NACK is working with ASTM to develop national standards for nanofabrication manufacturing education and skill sets for technician 2-year degree and shorter certificate programs.*



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- *NACK has led the development of remote access to its tools, and has developed partner sites in the different regions and time-zones in the U. S. to allow this equipment to be available widely in both rural areas and in locations where access to the equipment in an education setting is not available.*
- *NACK hosts workshop series for community college educators and administrators and university partners*
- *NACK is creating an alumni network for the graduates of all nanotechnology AAS degree programs in the United States*
- *NACK is working with ASTM to develop national standards for nanotechnology education and skill sets for technician 2-year degree and shorter certificate programs.*
- *NACK has led in the development of the annual Micro/Nanotechnology conference which has brought together 250 educators from community colleges, universities and high schools together with industry and government leaders to share best practices in nano programs and curriculum in the past 3 years.*



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- *Service to the State and community*
- *Supporting local economic development*
- *Can build support for user facilities at research university (resource sharing)*
- *Graduate student support (need TAs)*
- *Post-doc support (need skilled teachers)*
- *Research support*
- *Pipeline of students from community colleges to 4-year degree programs and beyond*



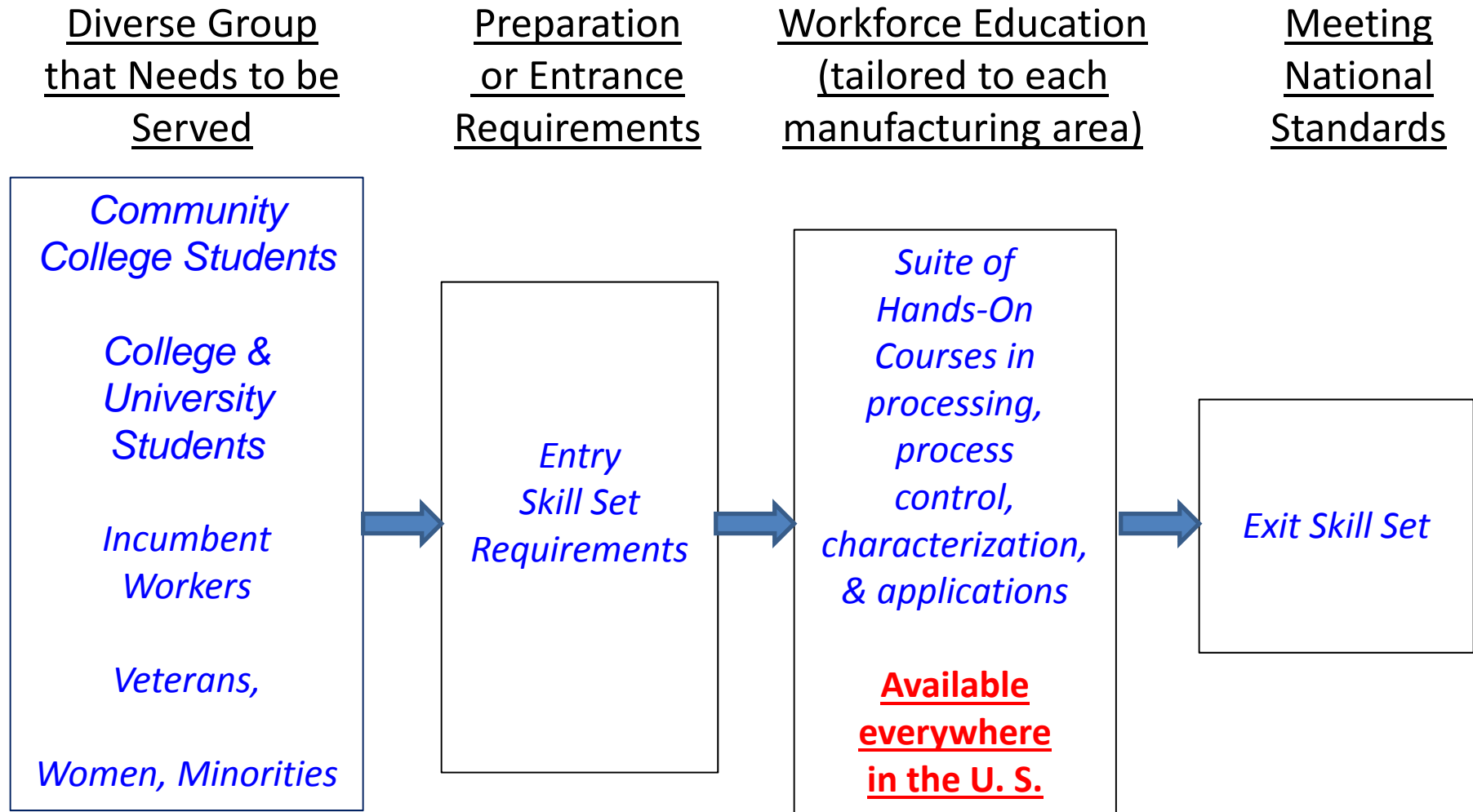
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Conclusion

A Successful Education Model Applicable to Advanced Manufacturing Centers



- *A one-semester hands-on immersion to manufacturing technology.*
- *Courses taught at the sophomore level- ideal for permitting one suite of courses for community college students, 4-year students, and incumbent technicians.*
- *Hands-on components taught at research university, community college, industry, and national lab hub sites (where there is equipment and resources to support it) .*
- *Classroom components taught at research universities and community college hubs.*
- *Classroom component lectures available on the web as PowerPoint presentations and as videos.*
- *Classroom component videos available with Spanish subtitles.*
- *Lab components also available as videos for students limited by travel distances to hubs.*

- *Lab components augmented by web remote-access to equipment operation and to characterization tools.*
- *PSU College of Engineering undergraduate manufacturing technology certificate.*
- *Working on a graduate level distance learning M.S. degree.*
- *Assessment rubrics developed with College of Education.*
- *Exit skill set resulting from the suite of courses is industry established and reviewed annually by industry for rapid evolution, as needed.*
- *Exit skill set is embedded in American Society for Testing and Materials standards.*



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Conclusion

- *Partnerships involving research universities and 2-year degree and 4-year degree institutions which utilize resource-sharing are very effective in delivering nanofabrication manufacturing education.*
- *The approach developed at CNEU/NACK is very viable in forming these partnerships. It relies on utilizing the teaching facilities, web capabilities, characterization tools, and faculty expertise at one (or perhaps several) advantageously and geographically positioned location(s).*
- *CNEU/NACK efforts are designed to insure that students emerging from US programs have an industry-established nanofabrication manufacturing skill set in synthesis, processing, characterization, and applications, and have a broad nanotechnology educational foundation on which the students can build upon throughout their professional careers.*

Conclusion (cntd.)

- *The resources provided by CNEU/NACK and shared with partnering institutions include:*
 - *Lecture and laboratory experiment sets for six complete courses.*
 - *Web available lectures (power-point and video formats) for the six courses to aid institutions in offering these courses.*
 - *Educators workshops on how to teach these six course.*
 - *Web access to state-of-the-art tools to enable the teaching of nano-characterization at workforce training institutions and, with NSF support, sends NACK experts to these institutions to assist faculty in learning and using these web accessible tools.*
 - *Modules for use in recruiting, introductory courses in nanofabrication manufacturing, or general public education.*
 - *Web resources, e. g., webinars, alumni network, discussion boards, etc.*
- *CNEU/NACK's model can be successfully applied to other types of advanced manufacturing, such as additive manufacturing.*



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Questions ??

