

Industry Surveys and National Skill Standards for Advancing Nanotechnology Education: A Status Update

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NACK Network / University of Puerto Rico Workshop
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Acknowledgement

Industry Survey

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- Rick Hansen
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Education Standards

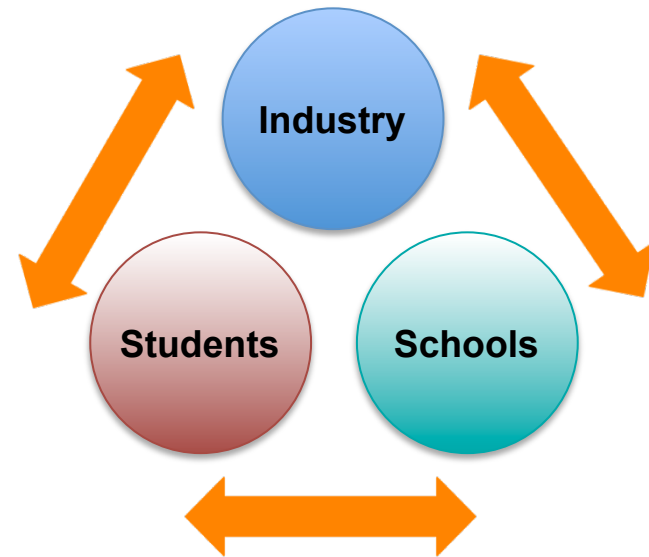
- Bob Ehrmann
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- Terry Kuzma
(*Pennsylvania State Univ.*)
- Peter Kazarinoff
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- Rick Hoover
(*Pennsylvania St. Univ., Ret.*)

Industry Surveys

The Need for Industry Surveys



- Students of 2-year schools tend to stay in area after graduation
- An area usually has a local or regional emphasis on particular industry sectors
- Educational programs/degrees should have breadth but also address local industry requirements
- Surveys are a good way to determine what the requirements are as well as the hiring plans of local companies
- Information gathered is very useful to schools for program/degree justification and/or customization of curriculum
- Engagement of local industry also facilitates their participation in Advisory Boards as well as opens up the potential of internship opportunities for students and funding/equipment support



Examples of Prior Industry Surveys Related to Nanotechnology Education

- Pennsylvania State University
- Northwest Vista College, TX
- Ivy Tech Community College, IN
- University of Puerto Rico at Humacao
- Oklahoma Nanotechnology Initiative
- Southwest Center for Microsystems Education, NM
- Chippewa Valley Technical College, WI

Current Survey in Arizona: A Case Study

- Joint effort between the Maricopa Community Colleges and Arizona State University (research university partner)
- Main objectives are to generate data to support initiation of degree programs in the state's 2-year schools and to optimize curriculum
- During planning stage, engaged the ASU School of Business that in 2011 conducted a broad study related to AZ's technology workforce
- Gathered useful tips plus, importantly, contact information for those that responded during the 2011 Workforce Survey – *getting a survey to the right person in a company is an important first step*
- Also engaged the AZ Nanotechnology Cluster for support
- Online survey design is based on that previously used by PSU
- Invitations to participate in survey first emailed in mid-September, and survey is presently still open

Survey Form (Part 1)

1. Your contact information _____

For companies with multiple locations, we are asking facility-level managers to complete this survey just for their facility.

2. How large is your company/facility?

49 or less people 50-499 people 500 or more people

3. General information

a) What products/parts/services are provided by your company/facility? In other words, which industry industry segment is your company/facility providing these products/parts/services for? (Check all that apply)

<input type="checkbox"/> Aerospace/Defense	<input type="checkbox"/> Agriculture/Food	<input type="checkbox"/> Automotive
<input type="checkbox"/> Biological	<input type="checkbox"/> Biotechnology	<input type="checkbox"/> Chemical
<input type="checkbox"/> Communications	<input type="checkbox"/> Electronics	<input type="checkbox"/> Environmental
<input type="checkbox"/> Equipment	<input type="checkbox"/> Industrial processing	<input type="checkbox"/> Machine tools
<input type="checkbox"/> Materials	<input type="checkbox"/> Medical devices	<input type="checkbox"/> Optics
<input type="checkbox"/> Pharmaceutical	<input type="checkbox"/> Other _____	

b) Does your company/facility currently use some aspect of micro- or nano-scale technology (in products, services, processes, tooling, etc.)?

No Yes (Please provide more information _____)

4. Do you employ technicians/engineering assistants?

No (Jump to Question 7 if you answered "No") Yes

5. What is the approximate number of technicians/engineering assistants you employ? _____

Survey Form (Part 2)

6. Do you anticipate hiring technicians/engineering assistants at your company/facility?

- | | | |
|---|---|--|
| <input type="checkbox"/> Need to hire now | <input type="checkbox"/> Within 3 years | <input type="checkbox"/> Possibly in 5 years or more |
| <input type="checkbox"/> Within 1 year | <input type="checkbox"/> Within 3-5 years | <input type="checkbox"/> No |

7. If we could tailor a technician education program to meet the needs of your company/facility, what knowledge and/or hands-on skills would you like them to have upon hiring? (Select all that apply)

- | | | |
|---|---|---|
| <input type="checkbox"/> safety and environmental hazards training | <input type="checkbox"/> optical, e-beam, and ion beam lithography | <input type="checkbox"/> chemical, physical, and/or biological self-assembly |
| <input type="checkbox"/> pumps, flow control systems, scrubbers, and sensors: use and maintenance | <input type="checkbox"/> stamping and imprinting lithography | <input type="checkbox"/> block co-polymer and self-assembled monolayers |
| <input type="checkbox"/> vacuum systems: use and maintenance | <input type="checkbox"/> optical microscopy | <input type="checkbox"/> fabricating nanoparticles: various |
| <input type="checkbox"/> plasma generating systems: use and maintenance | <input type="checkbox"/> scanning probe/atomic force microscopy | <input type="checkbox"/> chemical and physical vapor deposition systems |
| <input type="checkbox"/> furnances, ovens, rapid thermal annealing equipment: use and maintenance | <input type="checkbox"/> electron microscopy (SEM, FESEM, TEM) | <input type="checkbox"/> statistical process control |
| <input type="checkbox"/> reactive ion etching | <input type="checkbox"/> chemical characterization (mass spectroscopy, energy dispersive spectroscopy) | <input type="checkbox"/> professional/soft skills (team building, problem solving, presentation, project planning, technical reporting/writing, handling intellectual property, etc.) |
| <input type="checkbox"/> sputtering | <input type="checkbox"/> electrical characterization (C-V/I-V, capacitance) | |
| <input type="checkbox"/> wet etch and/or lift off | <input type="checkbox"/> physical characterization (spectrophotometry, profilometry, x-ray diffraction) | |

Other (please specify) _____

8. If a program as described in Question 7 exists, would you encourage your current employees to enroll in relevant courses in the program for continuing education?

- Yes No

9. Additional comments _____

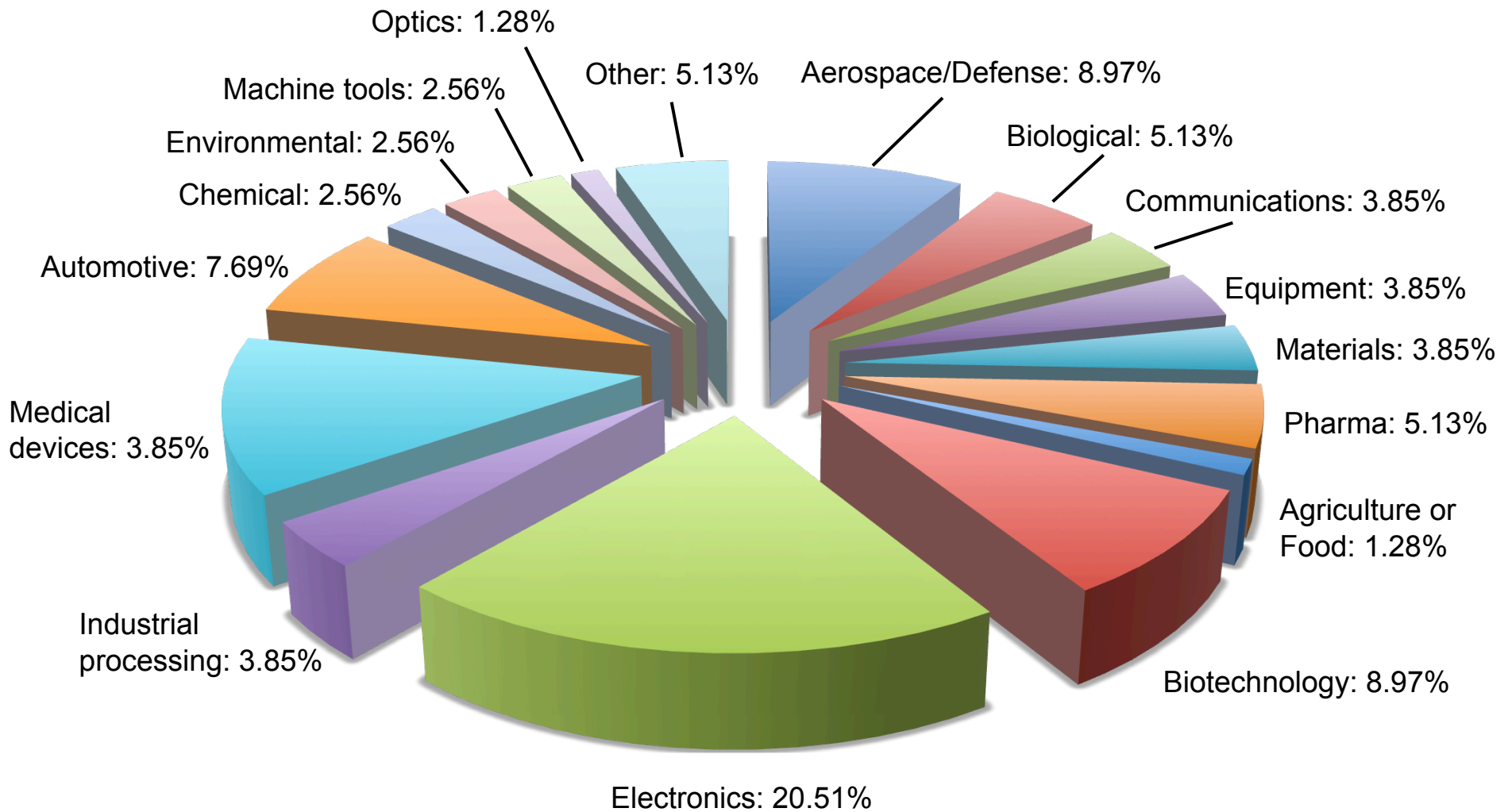


Preliminary Survey Results

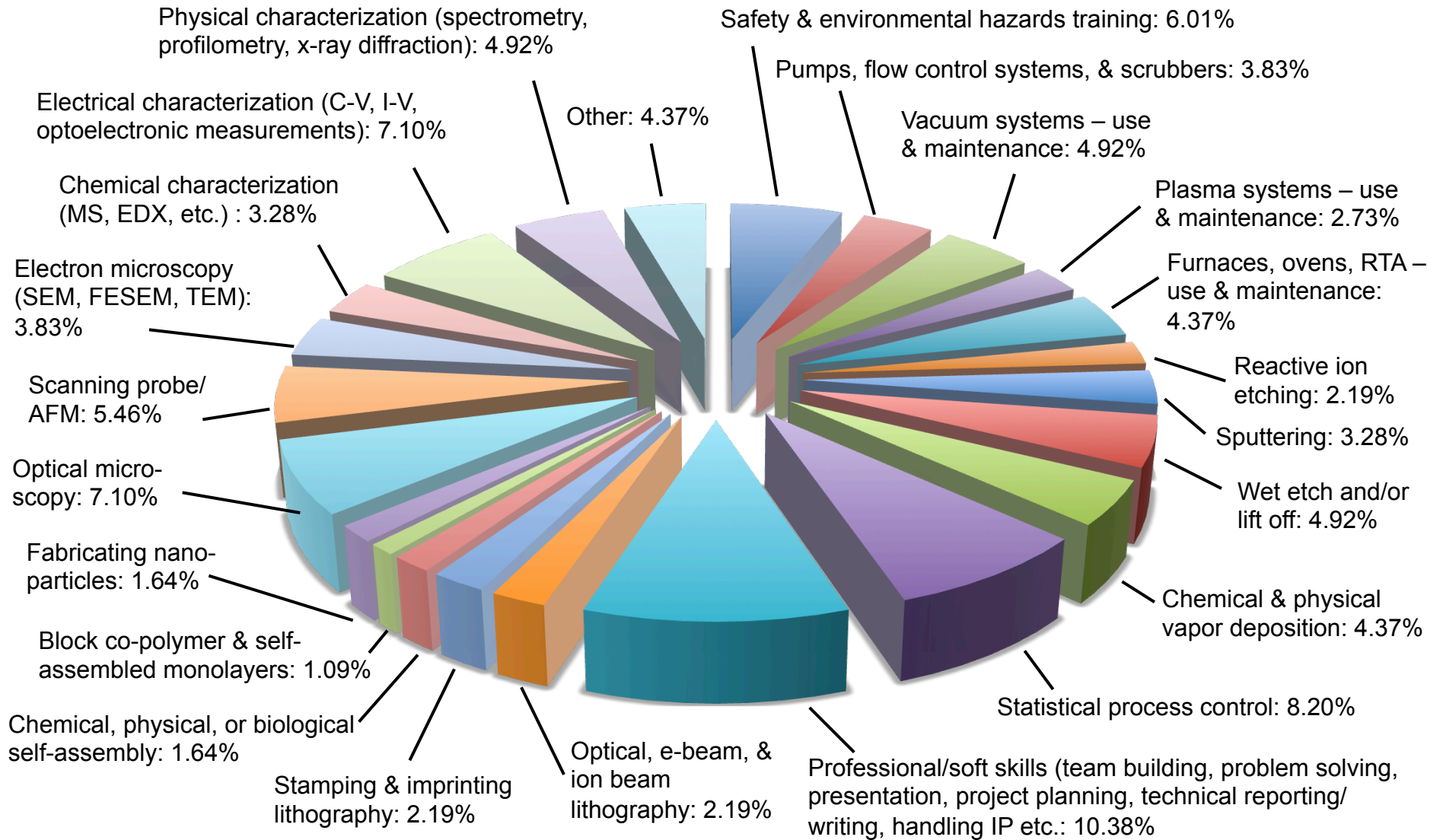
- Invitations to participate emailed directly to 46 technology companies with a presence in AZ, plus forwarded to members of the AZ Nanotechnology Cluster and AZBio (AZ BioIndustry Association)
- As of Nov. 9th, the response statistics for the survey webpage were:
VIEWED: 82 STARTED: 59 COMPLETED: 25 (42%)
- Companies that completed the survey fit the following descriptions:

<u>Facility Size</u>	<u>Uses Micro- or Nano-Scale Technologies</u>
○ Small (≤ 49 people) – 58%	○ Yes – 72%
○ Medium (50 to 499) – 17%	○ No --- 28%
○ Large (500 or more) – 25%	
- 80% of the responding companies reports employing technicians or engineering assistants (ranging from 1 to >50 positions)

Products/Parts/Services by Company/Facility



Knowledge/Skills Desired by Company/Facility



Other Preliminary Survey Results

Hiring Forecast

- Need to hire now – 20%
- Within 1 year – 40%
- Within 3 years – 15%
- In 3-5 years – 15%
- Not hiring – 20%

Other Skills Desired

- Handling chemicals and high voltage
- Basic knowledge and troubleshooting of automated equipment
- Manual and robotic pipetting

Enroll Current Staff for Continuing Ed?

- Yes – 84%
- No --- 16%

Select Comments

- “Hands-on experience a big plus.”
- “We need technicians that know basics. How to use tools, operate and repair equipment, handle dangerous stuff.”
- “... employ individuals with a life sciences, bio-engineering, bio-chem background ...”

Lessons Learned To Date

- Cast a wide net for the survey; useful to know even if an industry sector or company has no interest/need for the education program
- Leverage local/regional trade/professional organizations for contacts
- Keep survey relatively short; ours take on average 6 min to complete
- Persistence needed: use multiple email reminders and phone calls

Current Plans

- Continue calling those yet to complete survey
- Determine date to close survey website
- Define role of Industrial Advisory Board and compile list of potential candidates to contact
- Make follow-up calls to respondents for in-depth interviews
- Prepare report on survey results and distribute

Questions/Comments on Industry Surveys?

Standards for Nanotechnology Workforce Education

Standards Development Organizations (SDOs)

Global

- International Organization for Standardization
- International Electrotechnical Commission



Regional

- European Committee for Standardization



National

- DIN (Germany), JISC (Japan), SAC (China), etc.
(Note: NIST is not really a SDO; it is a NMI.)



Others

- ASTM, IEEE, SEMI, etc.



The Need for Standards

- Facilitate global trade and commerce
- Improve efficiency in manufacturing
- Provide safeguards to consumers of goods and services
- Accelerate R&D of emergent technologies
- Aid in technology transfer to developing nations
- Technical information on Environment, Health, Safety (EHS) issues for policy-makers and other stake-holders
- In the present case, nanotech is the emergent technology
- Education programs and their delivery are the goods and services
- Consumers are the students and the companies hiring them upon their graduation

Nanotech Workforce Education Standards

- Nanotechnology workforce education programs, in particular ones taught at 2-year/technical colleges, are springing up in many parts of the US
- Industry and government is strongly supportive of the development of these education programs, and would like to have program equivalency across the nation
- The NACK Network is a National Center in the Advanced Technology Education (ATE) program, funded by the National Science Foundation (NSF)
- It has taken on the task to create standard guides for existing and developing programs in nanotechnology workforce education

Role of Umbrella and Underlying Standards

- Defines a foundational set of standards for use in the education of the U.S. nanotechnology workforce
 - ❑ For existing programs and as a starting point for new programs
 - ❑ Defines a set of basic subject/technology areas
 - ❑ Defines a set of basic required skills/knowledge in each area
 - ❑ To be established as Standard Guides through ASTM's E56 Committee on Nanotechnology
- Provides a basis for uniformity in qualifications for graduates of nanotechnology workforce educational programs in the U.S, to meet both industry as well as academic needs

ASTM E56 Education Standards Planned

ASTM E yyy1

Standard Guide for the Basic Skill Set for Workforce Education in Nanotechnology

ASTM E xxx1

Standard Guide for Workforce Education in Nano Environment, Health & Safety (EHS)

ASTM E xxx2

Standard Guide for Workforce Education in Nanotechnology Characterization

ASTM E xxx3

Standard Guide for Workforce Education in Nanotechnology Infrastructure

ASTM E xxx4

Standard Guide for Workforce Education in Nanotechnology Synthesis & Processing

ASTM E xxx5

Standard Guide for Workforce Education in Nanotechnology Material Properties & Scale

ASTM E xxx6

Standard Guide for Workforce Education in Nanotechnology Pattern Generation & Transfer

NACK Network Skill Standards Development Subcommittee

Bob Ehrmann	Pennsylvania State University – PA NACK Network
Rick Hoover	Pennsylvania State University (retired)
Peter Kazarinoff	North Seattle Community College – WA SHINE Regional ATE Center
Terry Kuzma	Pennsylvania State University PA NMT Partnership
Deb Newberry	Dakota County Technical College – MN NanoLink Regional ATE Center
Ray Tsui	Arizona State University – AZ NACK Network

NACK Network Skill Standards Development Process

- Creation of draft standard by the NACK Network Skills Standards Development Subcommittee
- Review and revision by Chair of NACK Network's Industry Advisory Board and nanotechnology educators across the country
- Submission of revised draft to appropriate Subcommittee in ASTM E56 for review and approval via balloting
- Additional revisions as necessary by NACK Network Skills Standards Development Subcommittee
- Re-balloting within E56 for final approval and publication by ASTM

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Standard Guide for Workforce Education in Nanotechnology Synthesis & Processing

ASTM E xxx5

Standard Guide for Workforce Education in Nanotechnology Material Properties & Scale

ASTM E xxx6

Standard Guide for Workforce Education in Nanotechnology Pattern Generation & Transfer

Intended Scope of Standard Guide for Workforce Education in Nano-Related EHS Topics

- Set guidelines for the basic education of environment, health and safety (EHS) topics for nanoscale materials and structures, to be taught at an undergraduate college level
 - ❑ To be broad range of EHS topics relevant to the workforce
 - ❑ Facilitates the preparation of an individual to work in various capacities in one or more of the many areas in nanotechnology
- May be used to develop/evaluate an education or training program for EHS topics in the nanotechnology field
 - ❑ Provides listings of key topics that should be covered
 - ❑ Does not provide specific course material to be used
- Not intended for use in EHS certification

Standard Guide for Workforce Education in Nano EHS Topics: Development History

- Aug/Sept 2011 1st Ballot by ASTM E56 – 61% of votes were in the Affirmative; those voting No suggested revisions
- Feb 2013 NACK Skills Standards Subcommittee reorganized
- April 2013 Revised document created, incorporating most of the commentary and improvement suggestions from original document
- May 2013 Encouraged by E56 to continue standard development
- Oct 2013 Sent revised guide to E56 members who provided 2011 commentary
Made presentation on progress and plans at a E56 Committee Meeting – responses were positive
- Dec 2013 Make minor revisions to guide and submit to E56 for re-ballot

ASTM E56 Education Standards Planned

ASTM E yyyy

Standard Guide for the Basic Skill Set for Workforce Education in Nanotechnology

ASTM E xxx1

Standard Guide for Workforce Education in Nano Environment, Health & Safety (EHS)

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ASTM E xxx6

Standard Guide for Workforce Education in Nanotechnology Pattern Generation & Transfer

Intended Scope of Standard Guide for Workforce Education in Nanotech Characterization

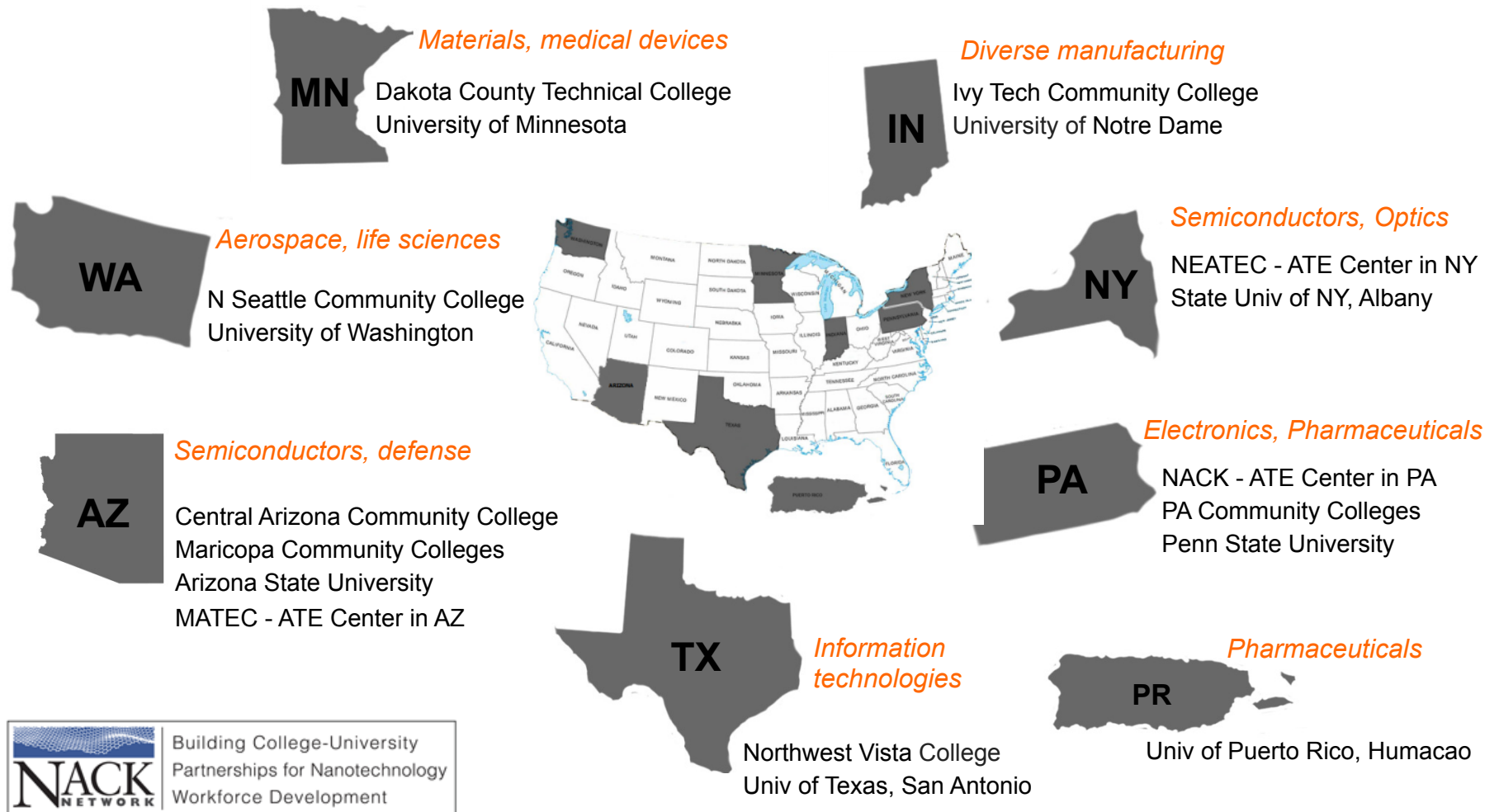
- Set guidelines for the basic education of characterization methods for nanoscale materials and structures, to be taught at an undergraduate college level
 - ❑ To be broad and include a suite of characterization methods
 - ❑ Facilitates the preparation of an individual to work in various capacities in one or more of the many areas in nanotechnology
- May be used to develop/evaluate an education or training program for characterization in the nanotechnology field
 - ❑ Provides listings of key topics that should be covered
 - ❑ Does not provide specific course material to be used
- Not intended to cover all of the nanoscale characterization methods, nor meant for use in certification

Challenges in Development of Standard

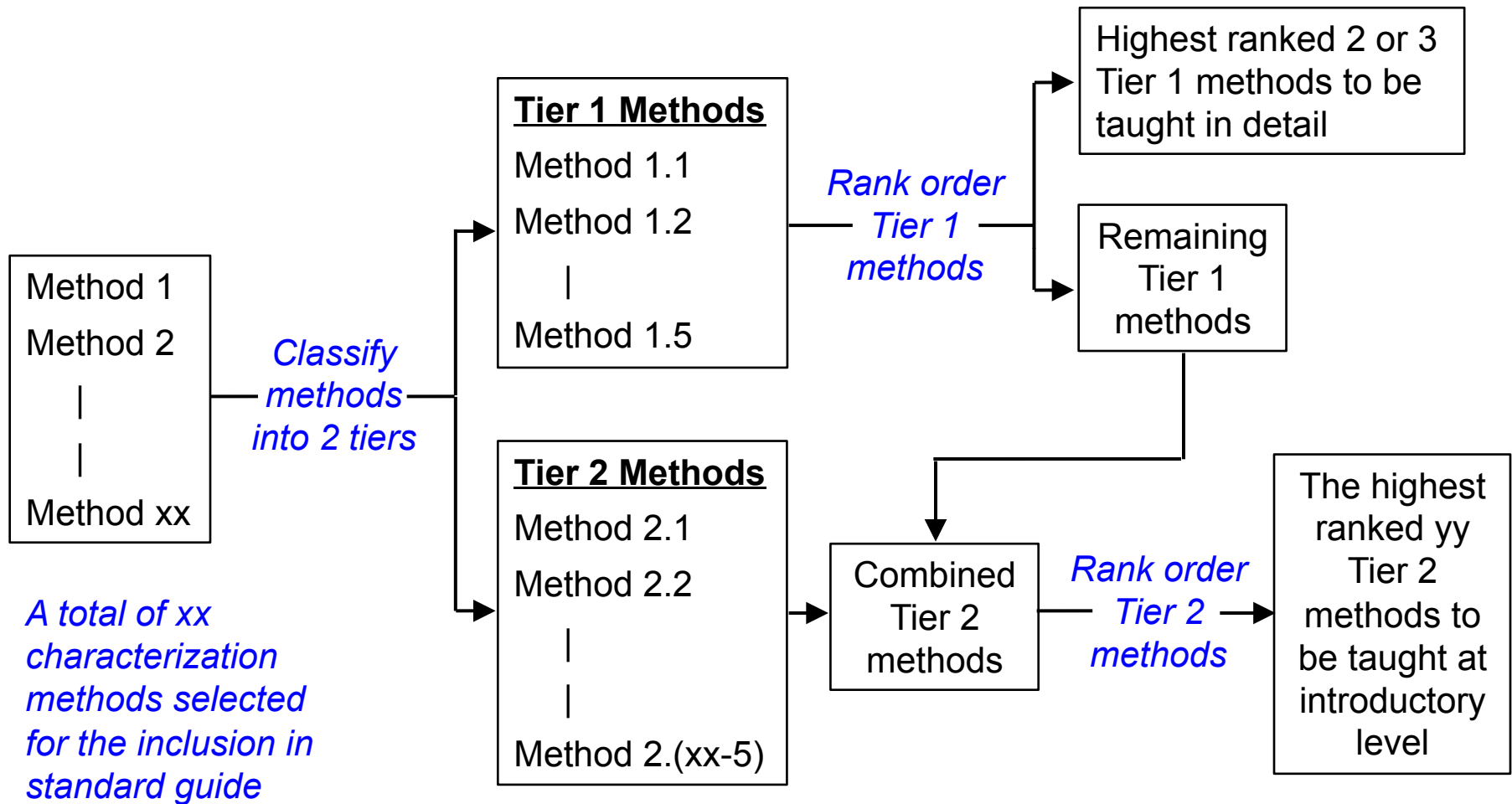
- How to structure the standard to be comprehensive and also uniformly applicable to existing and new programs
- List of methods is extensive and techniques vary widely in level of complexity
- For example, BSI PAS 133:2007 (“Terminology for Nano-scale Measurement and Instrumentation”) lists over 70 methods in 9 categories
- Even if complex methods are excluded, still insufficient time in a 2-year degree program to cover a long list of methods in great depth to ensure competency
- Access to instrumentation available for teaching usually is limited and also varies from school to school
- Situation further challenged by regional differences in skill set needed by local companies

Diverse Needs of Regional Employers

- Local industries will require different emphasis on graduates' skill sets
- Standard ideally has sufficient flexibility to accommodate this

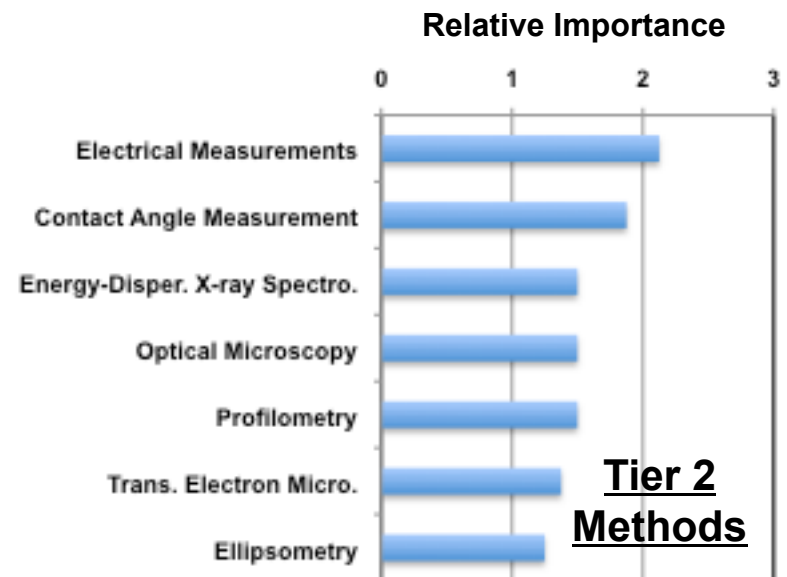
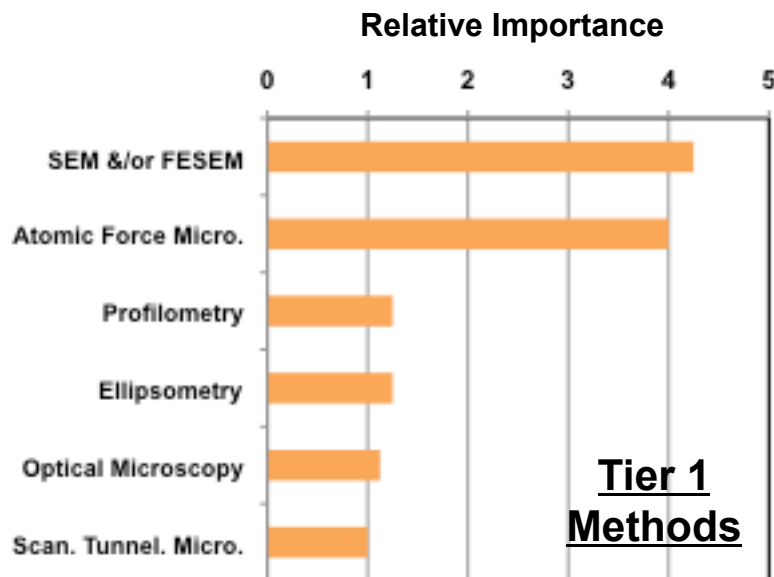


A 2-Tier Approach is Proposed



Ranking of Methods by Nanotech Educators

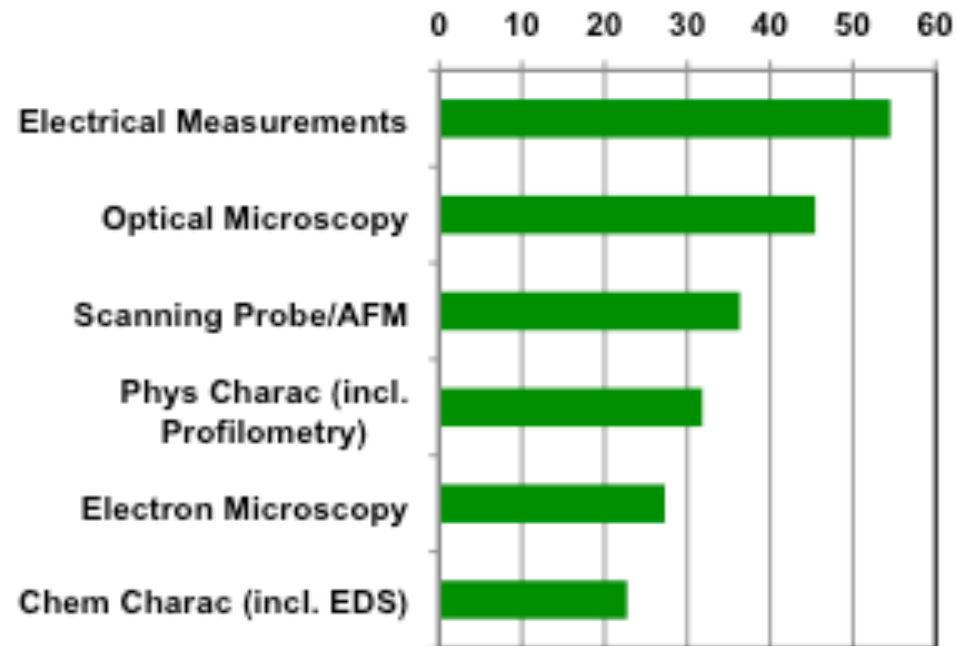
- Educators polled for tier classification and method ranking
- Charts below show results of methods ranked on a relative scale of 0-5 (5 = most important)
- Data suggest proposed 2-tiered approach is workable



Preliminary Data from Industry Survey

- From on-going industry survey in AZ, conducted by NACK Network's Southwestern-US education hub
- Results to-date consistent with educators' inputs on method selection and rankings

Percentage of Responding Company Desiring This Skill in Education Program



Summary for Standards Development

- Planning development of a set of standard guides for workforce education in various nanotech-related subject areas, to provide a basis for uniformity in graduates' qualifications
- Standard guide for workforce education in nanotech-related EHS topics close to ready for re-submission to ASTM's E56 Committee on Nanotechnology for 2nd Ballot
- A 2-tiered approach is proposed in structuring a standard guide for workforce education in nanotech characterization
 - ❑ Offers the flexibility of tailoring to regional needs while still retaining a high degree of equivalency in educational depth and breadth
 - ❑ Will incorporate positive feedback on the approach received from E56 into preparation of a first draft suitable for balloting
- A standard guide for workforce education in the infrastructure needed for nanotechnology will likely be next

Questions? Comments?