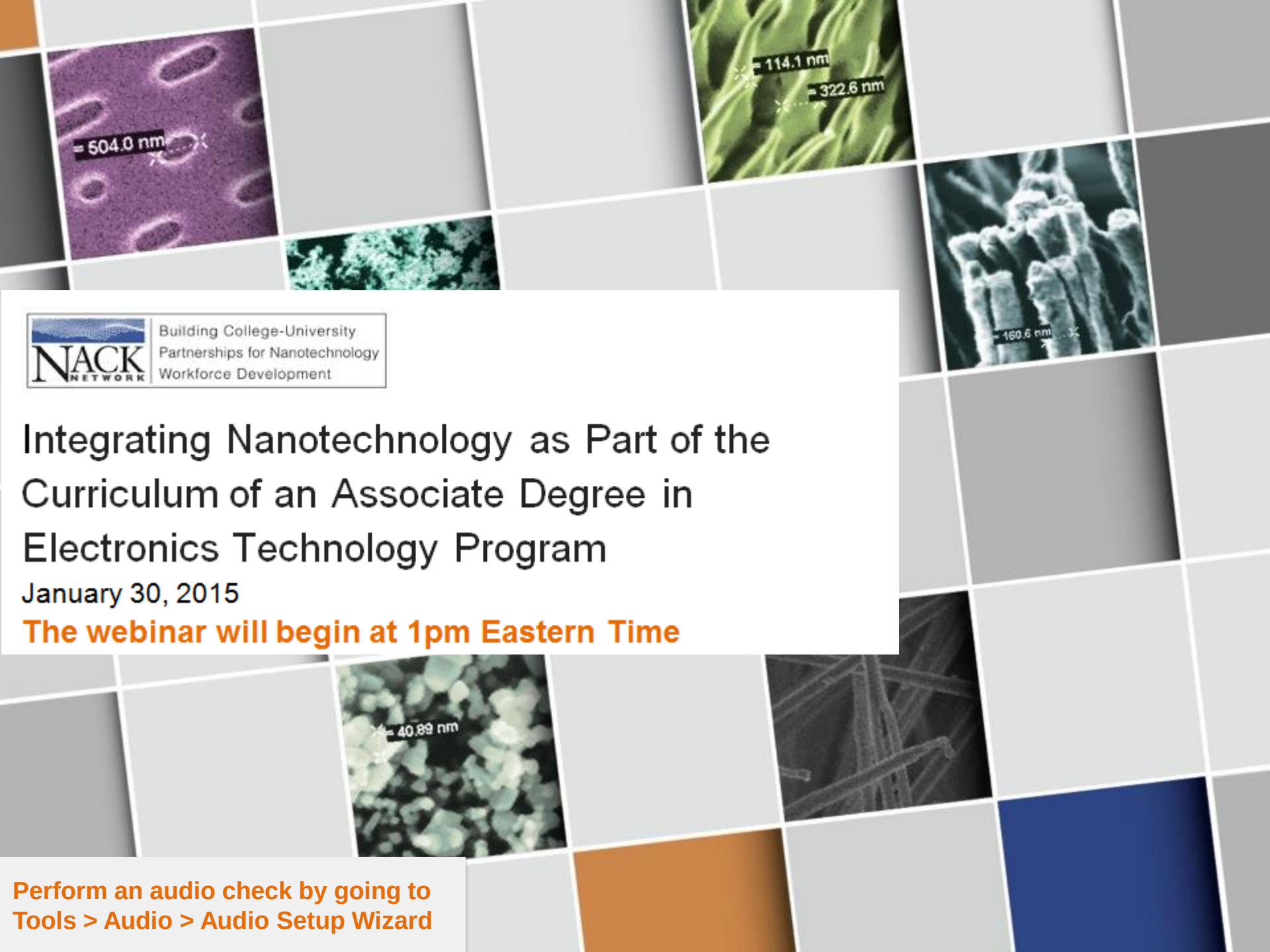

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Building College-University Partnerships for Nanotechnology Workforce Development

Integrating Nanotechnology as Part of the Curriculum of an Associate Degree in Electronics Technology Program

January 30, 2015

The webinar will begin at 1pm Eastern Time

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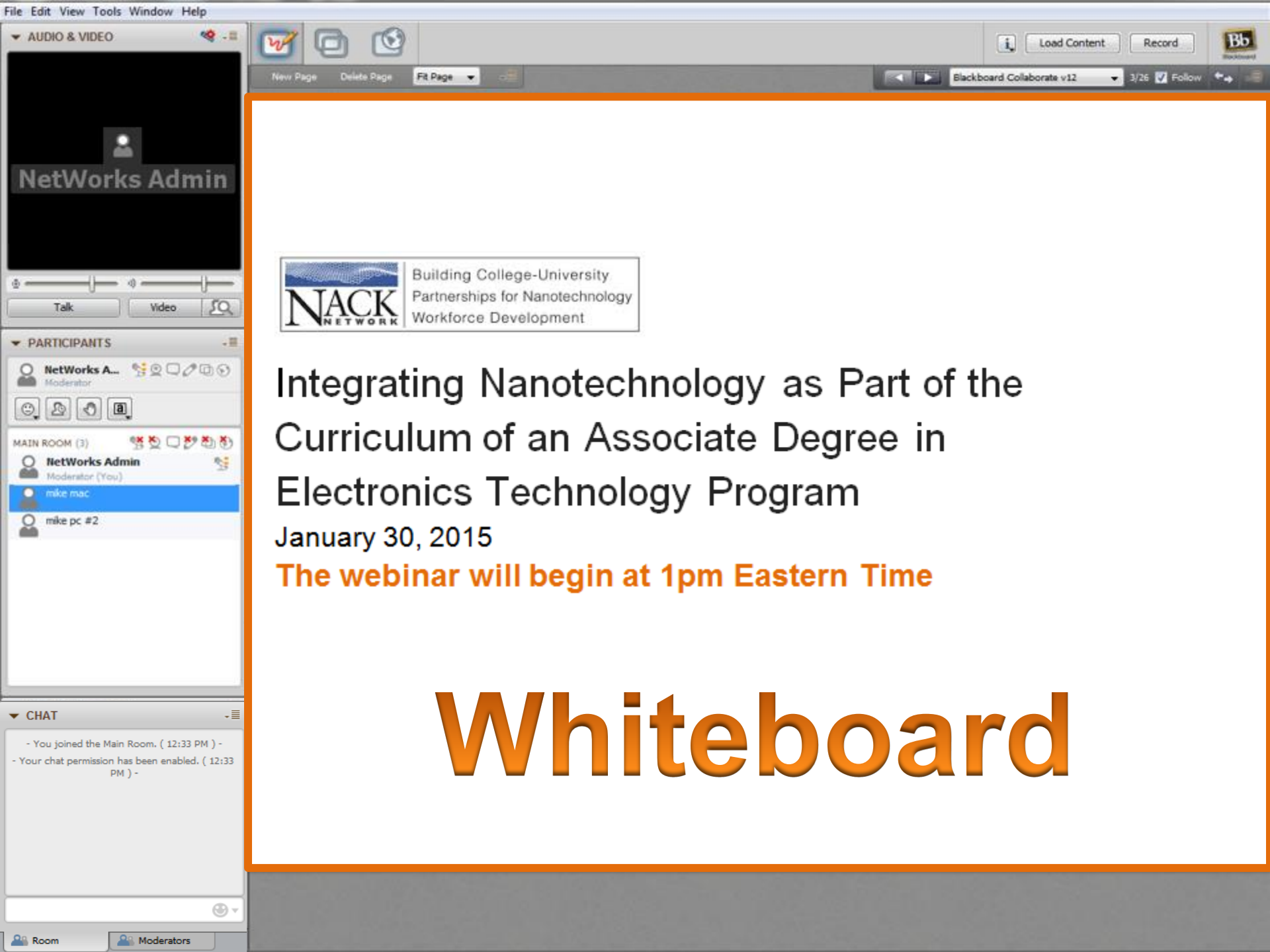
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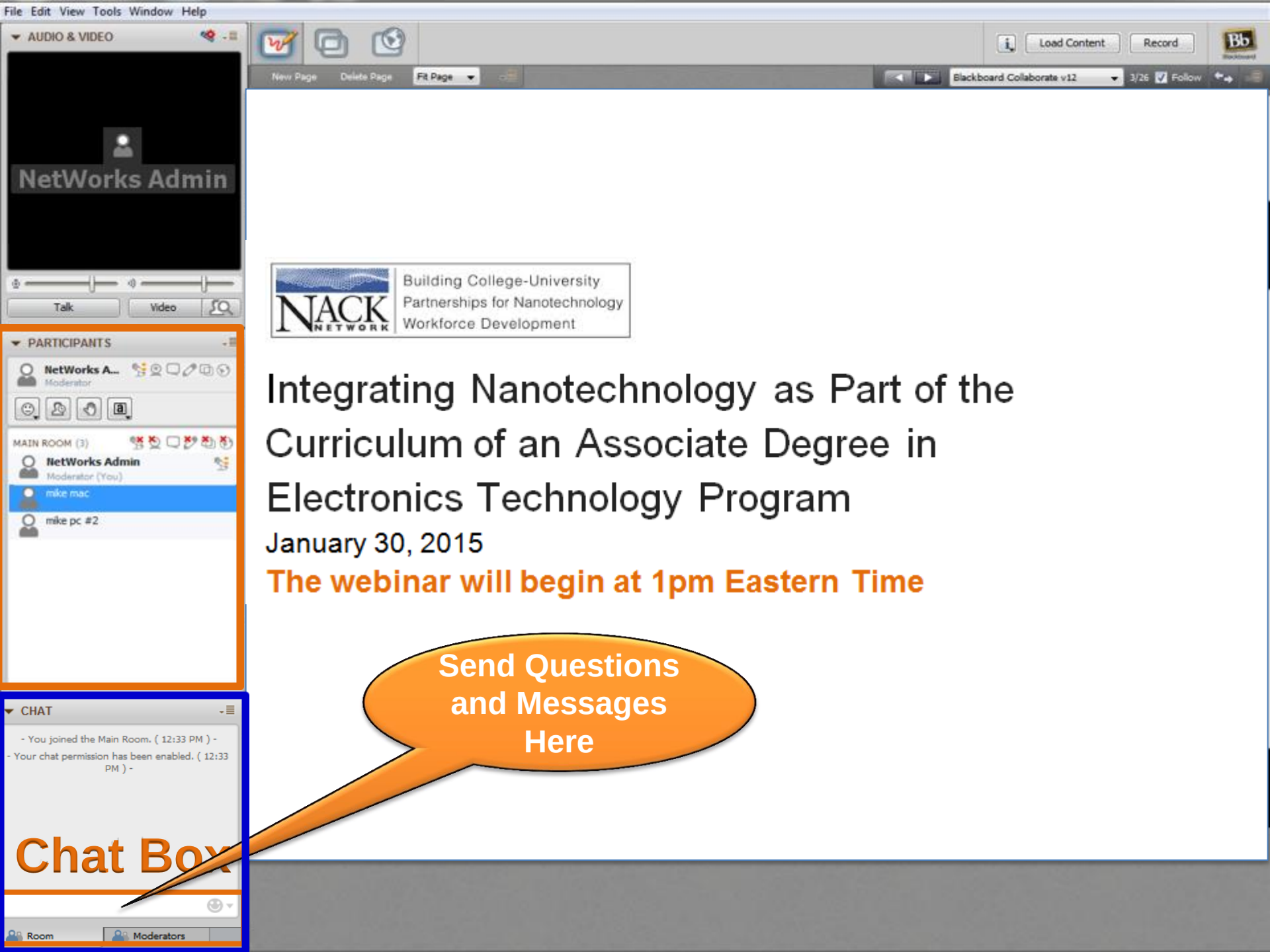
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The NACK Network, established at the Pennsylvania State College of Engineering, and funded in part by a grant from the National Science Foundation (DUE 1205105).

Hosted by MATEC NetWorks ***www.matecnetworks.org***

Today's Presenter

Dr. Josee Védrine-Pauléus

Dr. Védrine received her Ph.D. in electrical engineering in 2005 from Brown University, with a thesis on flexible display systems. She went on to work as a consultant at the World Bank Institute and joined the development team for The Nelson Mandela African Institute of Science and Technology (NM-AIST). She returned to academia as a postdoctoral researcher at Princeton University researching block copolymeric materials for nanostructures fabrication. She currently holds an associate professorship at the University of Puerto Rico-Humacao in the Department of Physics and Electronics, and has been a part of the NACK Network since 2009.

Moderator: **Robert Ehrmann, NACK Network**

Host: Roxanna Montoya MATEC

Objectives

- Gain insight on how to integrate nanotechnology courses into curriculum using NACK Network resources
- Explore a proven model at the University of Puerto Rico – Humacao Campus
- Discover methods for improving programs; making them more attractive to potential students and employers

Nanotechnology in Electronics Technology Associate Degree

Josee Vedrine (presenter)
Rogerio Furlan, Luis G. Rosa
nackuprh@gmail.com

UPR
HUMACAO

University of Puerto Rico

- Public University
- 11 campuses
- ~50,000 students

UPR HUMACAO

- 2 and 4 year undergraduate campus
- ~3,500 students, ~65% female
- ~85% of the students receive Pell Grants
- ~75% of the students graduated from public HS
- ~38% of the students are enrolled in science related programs (Physics Applied to Electronics, Biology, Chemistry and Computational Mathematics)

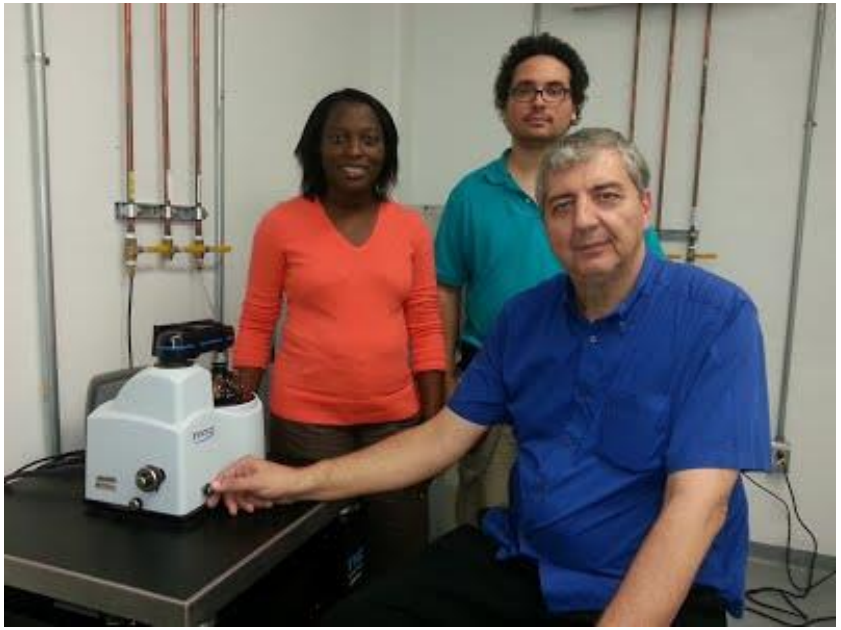
UPRH's Target and Service Areas

Target areas :16 municipalities

- Key industrial areas: biotechnology, medical devices, pharmaceutical, agro biotechnology, aerospace, information technology, apparel manufacturing, creative industries and export services. Puerto Rico is one of the most important biopharmaceutical manufacturing centers in the world.

Participation of UPRH in the NACK Center/Network

- UPRH's Physics and Electronics Department has been a member of the NACK Network since 2008



From left: Dr. Josee Vedrine-Pauléus , Dr. Luis G. Rosa, and Dr. Rogerio Furlan

Participation of UPRH in the NACK Center/Network

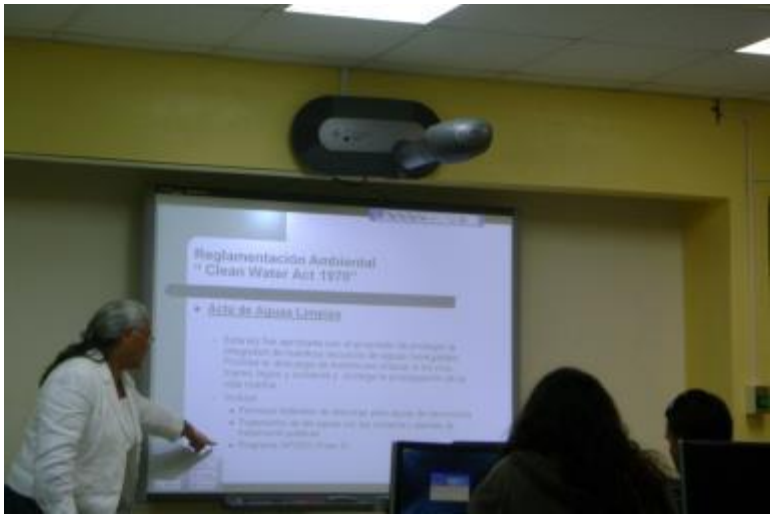




- Nanotechnology workshop courses based on the courses of the Pennsylvania State's Nanofabrication Capstone Semester (www.nano4me.org) have been offered at UPRH, one per semester, through our continuing education program, at no charge for participants:

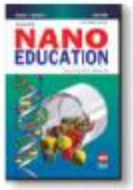
Course Titles

- Materials, Safety, and Equipment Overview for Nanotechnology
- Basic Nanotechnology Processes
- Materials in Nanotechnology
- Patterning for Nanotechnology
- Materials Modification in Nanotechnology (changed to Nanotechnology Applications)
- Characterization, Testing of Nanotechnology Structures, and Materials



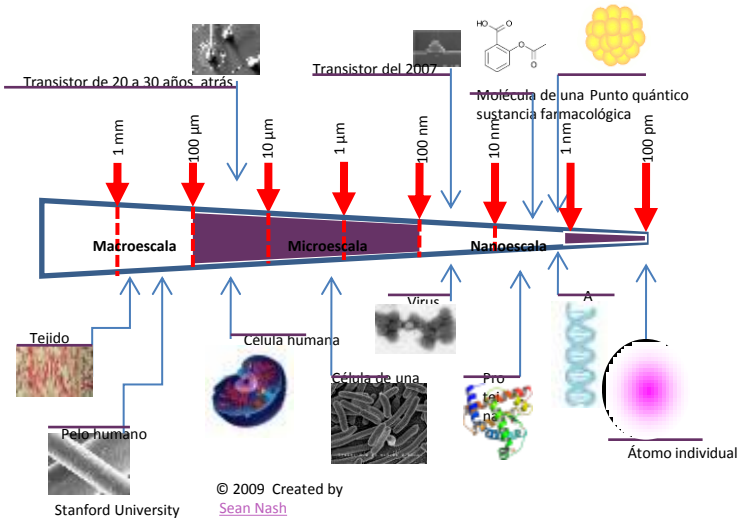
www.nano4me.org Course Codes: ESC 211 – ESC 216

Participation of UPRH in the NACK Center/Network

- 

Implementing a Training Program for the Nanotechnology Workforce at the University of Puerto Rico

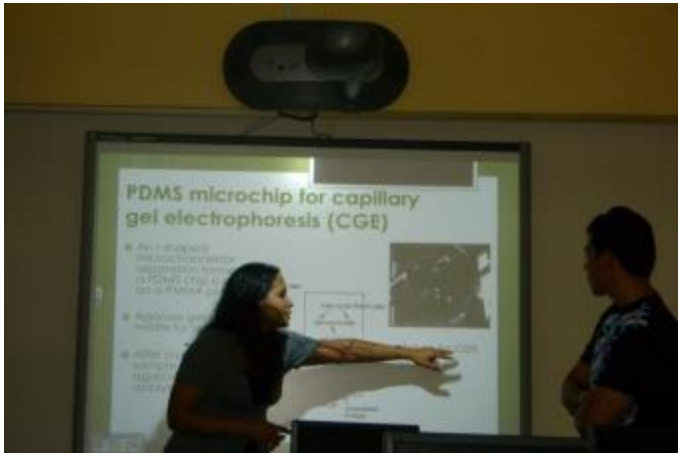
- Spanish translation modules
  - Introductory level modules (Módulo 1: Nanotecnología: ¿Qué es y porqué se considera tan importante ahora?)
  - Undergraduate materials (ESC 211-216)
- Translated modules available at www.nano4me.org



Participation Continued

UPR
Universidad de Puerto Rico

- One hundred seventy seven (177) certificates awarded to participants who successfully completed workshops as of December 2014, through Continuing Education Office.
- 26% of the participants were students of our Associate Degree in Electronics Technology.
- Two nanotechnology courses were defined with basis on this experience and included in the Associate Degree Curriculum (Industrial Nanotechnology Theory and Laboratory).



Hybrid Cleanroom for Nanotechnology Research and Education

UPR Universidad de Puerto Rico

PRIDCO PUERTO RICO INDUSTRIAL DEVELOPMENT COMPANY

- Synergistic grant from Puerto Rico Industrial Development Company (PRIDCO)

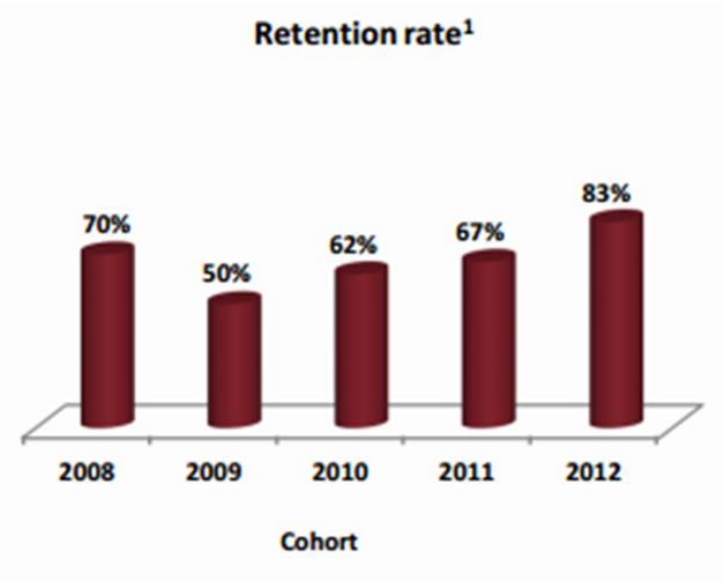
Nanotechnology laboratory (625 sq. ft.) including a 400 sq. ft. class 10,000 cleanroom

Associate Degree in Electronics Technology

- Program for students who desire enter workforce after short period of study (2 years)
- Develops in students a positive attitude towards the analytical processes
- Graduates are technically prepared and self-motivated to endeavor in their own businesses

Program Impact

- Admission: ~14 students per year (avg. last 5 years)
- Total enrollment: ~30 students
- Degrees awarded per year: ~5 (avg. last 5 years)



- Recent improvements aiming at increasing recruitment and retention:
  - Implementation of technical mathematics course
  - Inclusion of nanotech courses

Associate Degree in Electronics Technology: Curriculum

FIRST YEAR – FIRST SEMESTER				
Code	Credits	Name	Corequisites	Prerequisites
INGL-3101	3	Basic English I		
ESPA-3101	3	Basic Spanish I		
MATE- 1031	4	Fundamentals of Technical Mathematics I		
FISI-1031	3	Technical Physics I	MATE- 1031 FISI -1033	
FISI -1033	1	Technical Physics I Laboratory	FISI- 1031	
PSIC-1006	3	Human Relations in Industry		
SUBTOTAL	17			

FIRST YEAR – SECOND SEMESTER				
Code	Credits	Name	Corequisites	Prerequisites
INGL -3102	3	Basic English II		INGL-3101
ESPA-3102	3	Basic Spanish II		ESPA-3101
MATE-1032	4	Fundamentals of Technical Mathematics II		MATE- 1031
FISI-1032	3	Technical Physics II	FISI-1034 MATE-1032	FISI-1031/33 MATE- 1031
FISI -1034	1	Technical Physics II Laboratory	FISI-1032 MATE-1032	FISI-1031/33 MATE- 1031
TEEL-1021	3	Alternate Current Circuits	TEEL-1022 MATE-1032 FISI-1032/34	FISI-1031/33 MATE- 1031
TEEL-1022	1	Alternate Current Circuits Laboratory	TEEL-1021 MATE-1032 FISI-1032/34	FISI-1031/33 MATE- 1031
SUBTOTAL	18			

Curriculum Continued

SUMMER				
Code	Credits	Name	Corequisites	Prerequisites
TEEL-2015	2	Industry Practice		TEEL-1021/22 FISI-1032/34 MATE-1032
SECOND YEAR – FIRST SEMESTER				
Code	Credits	Name	Corequisites	Prerequisites
TEEL- 2031	3	Basic Electronics I	TEEL-2032	TEEL-1021/22 MATE-1032
TEEL- 2032	1	Basic Electronics I Laboratory	TEEL-2031	TEEL-1021/22
TEEL- 2111	3	Digital Electronics	TEEL-2112	TEEL-1021/22 MATE-1032
TEEL- 2112	1	Digital Electronics Laboratory	TEEL-2111	TEEL-1021/22
TEEL- 2007	3	Introduction to Computer Programming		MATE-1032
TEEL-2019	3	Introduction to Quality Control		MATE-1032
SECOND YEAR – SECOND SEMESTER				
Code	Credits	Name	Corequisites	Prerequisites
TEEL -2041	3	Basic Electronics II	TEEL-2042	TEEL-2031/32
TEEL -2042	1	Basic Electronics II Laboratory	TEEL-2041	TEEL-2031/32
TEEL -2121	3	Microprocessors	TEEL-2122	TEEL-2111/12
TEEL -2122	1	Microprocessors Laboratory	TEEL-2121	TEEL-2111/12
HIST-3245	3	History of Puerto Rico		
TEEL - 2131	3	Industrial Nanotechnology	TEEL-2041/42 TEEL-2132	TEEL-2031/32
TEEL - 2132	1	Industrial Nanotechnology Laboratory	TEEL-2041/42 TEEL-2131	TEEL-2031/32
SUBTOTAL	15			
TOTAL	68			

Technical Curriculum - Summary

- Electric Circuits (DC/AC)
- Basic Electronics (Analog & Digital)
- Microprocessors and Microcomputers
- Programmable Logic Controllers
- Introduction to Computer Programming
- Introduction to Quality Control
- Introduction to nanotechnology and related technologies
- Industry Practice (100 hours)

MOP

Colorcon

BIO-TECH

Medtronic

Questions?

Please type your questions in the chat box

Industrial Nanotechnology

- Offered from January 2014
- 3 hours per week / 15 weeks
- Use of NACK's instructional materials in theory: Introductory Level Modules and Undergraduate Materials (www.nano4me.org)
- Experiments developed using local facilities/equipment and kits
- Laboratory taught by faculty and lab technician (maximum of 5 students per group/3 groups)

Industrial Nanotechnology Lectures

- **Introduction to nanotechnology:**
  - Nanotechnology: What Is It, and Why Is It So "BIG" Now? (Introductory Level Module 1)
  - A Brief History of Nanotechnology (Introductory Level Module 2)
  - A Snapshot of Nanotechnology Today (Introductory Level Module 3)
  - The Uniqueness of the Nano-scale (Introductory Level Module 4)
  - How Do You Build Things So Small: Top-Down Nanofabrication (Introductory Level Module 7)
  - How Do You Build Things So Small: Bottom-Up Nanofabrication (Introductory Level Module 8)
  - Nanotechnology: Impact on Microelectronics (Introductory Level Module 10)

- **Safety and environmental Concerns:**
  - General Safety Awareness, Safety, and Environmental Concerns (ESC211 – Unit 1 – Lecture 1)
  - Gas Safety, Biological Safety, and Nanomaterial Safety (ESC211 – Unit 1 – Lecture 2)
  - Energy, Safety, and Environmental Concerns (ESC211 – Unit 1 – Lecture 3)

- **Elements of vacuum systems:**
  - Overview of Vacuum Based Systems (ESC211 – Unit 2– Lectures 3 and 4)
  - Vacuum Gauges, Residual Gas Analyzers, Vacuum Valves (ESC211 – Unit 2– Lecture 5)
  - Vacuum Pumps, Vacuum Leaks (ESC211 – Unit 2– Lecture 6)

Industrial Nanotechnology Lectures, cont.

- **Electrical and magnetic materials:**
  - Classifying Materials by Physical Properties: Electrical Properties, Part I, II, and III (ESC211 – Unit 3– Lectures 7, 8, and 9)
  - Classifying Materials by Physical Properties: Magnetic Properties (ESC211 – Unit 3– Lecture 11)

- **Polymers:**
  - Organic and Inorganic Materials (ESC211 – Unit 3– Lecture 3)

- **Introduction to characterization techniques:**
  - How Do We "See" Things at the Nano-scale: An Introduction to Characterization Techniques (Introductory Level Module 5)

- **Manufacturing Processes:**
  - Plasma Basics (ESC212 – Unit 2– Lecture 1)
  - Dielectrics by Growth and Deposition (ESC215 – Unit 4– Lecture 1)
  - CVD/LPCVD (ESC212 – Unit 5 – Lecture 1)
  - PVD (ESC212 – Unit 6– Lecture 1)
  - PECVD (ESC215 – Unit 1 – Lectures 1)
  - Patten Transfer and Lithography Techniques (ESC212 – Unit 4– Lecture 1) and Movie (Silicon Run Lithigraphy - http://siliconrun.com) and Discussion
  - Dry Etching Chemistry (ESC215 – Unit 2 – Lectures 1 and 2)
  - Wet Etching (ESC212 – Unit 3 – Lecture 1)

- **Integrated Circuits Manufacturing:**
  - Movie (Silicon Run Lite - http://siliconrun.com) and Discussion

Industrial Nanotechnology Lectures, cont.

- **Materials in nanotechnology:**
  - An Introduction to Colloidal and Self-Assembled Materials (ESC213 – Unit 1 – Lectures 1 and 2)
  - An Introduction to Nanoparticles and Nanostructures (ESC213 – Unit 2 – Lecture 1)
  - An Introduction to Nanoparticle Synthesis and Applications (ESC213 – Unit 3 – Lecture 1)
  - Quantum Dot Physics, Synthesis, and Applications (ESC213 – Unit 4 – Lecture 1)

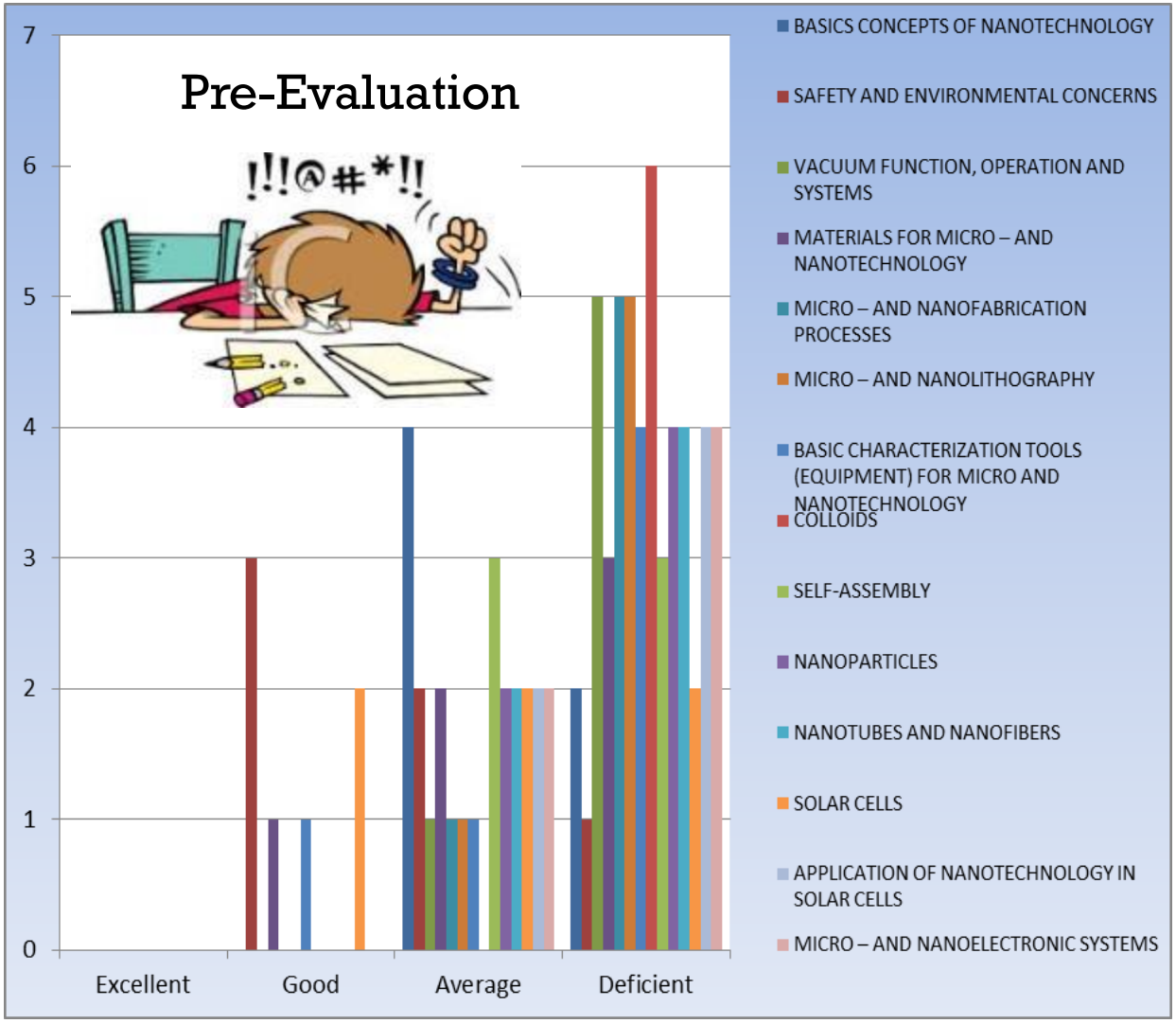
- **Solar cells:**
  - Organic Solar Cells (ESC215 – Unit 5 – Lecture 1)

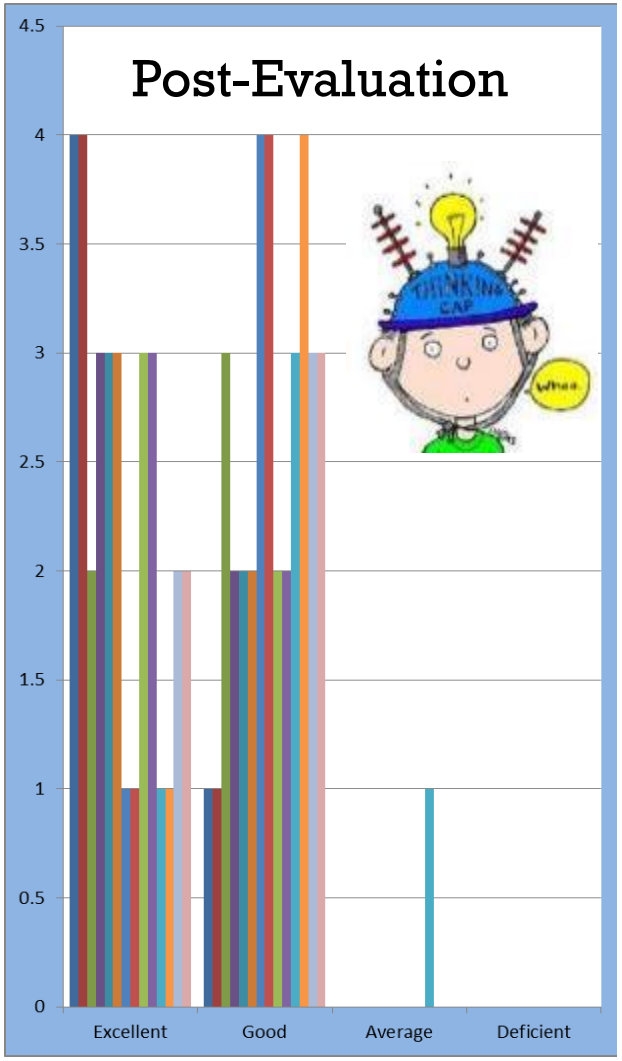
- **Introduction to Nano – and Microelectromechanical Systems (NMEMS)**:
  - Introduction to NMEMS, Bulk and Surface Micromachining and Applications (Sensors and Actuators) (Power Point prepared by R. Furlan)
  - Movie (MEMS – Making Micro Machines, Silicon Run http://siliconrun.com) and Discussion
  - Design of a Microfluidic devices: Flow Divider (Bulk Micromachining) and Flow Meter with Free-Standing Filaments (Surface Micromachining)

Industrial Nanotechnology Laboratory

- Safety and Environmental Concerns
- Cleanroom Protocol
- Vacuum Simulator (EquipSIM) and Demonstration of Vacuum System
- Optical Microscopy
- Ellipsometry
- Profilometry
- Atomic Force Microscopy (AFM)
- Scanning Electron Microscopy (SEM)
- Thermal Evaporation
- Sputtering
- Spin Coat and Optical Lithography
- Block Copolymers for Nanolithography
- Fabrication of Micro and Nanofibers using Electrospinning
- Fabrication and Characterization of Solar Cells using Nanotechnology

Pre/Post Evaluation – Industrial Nanotechnology

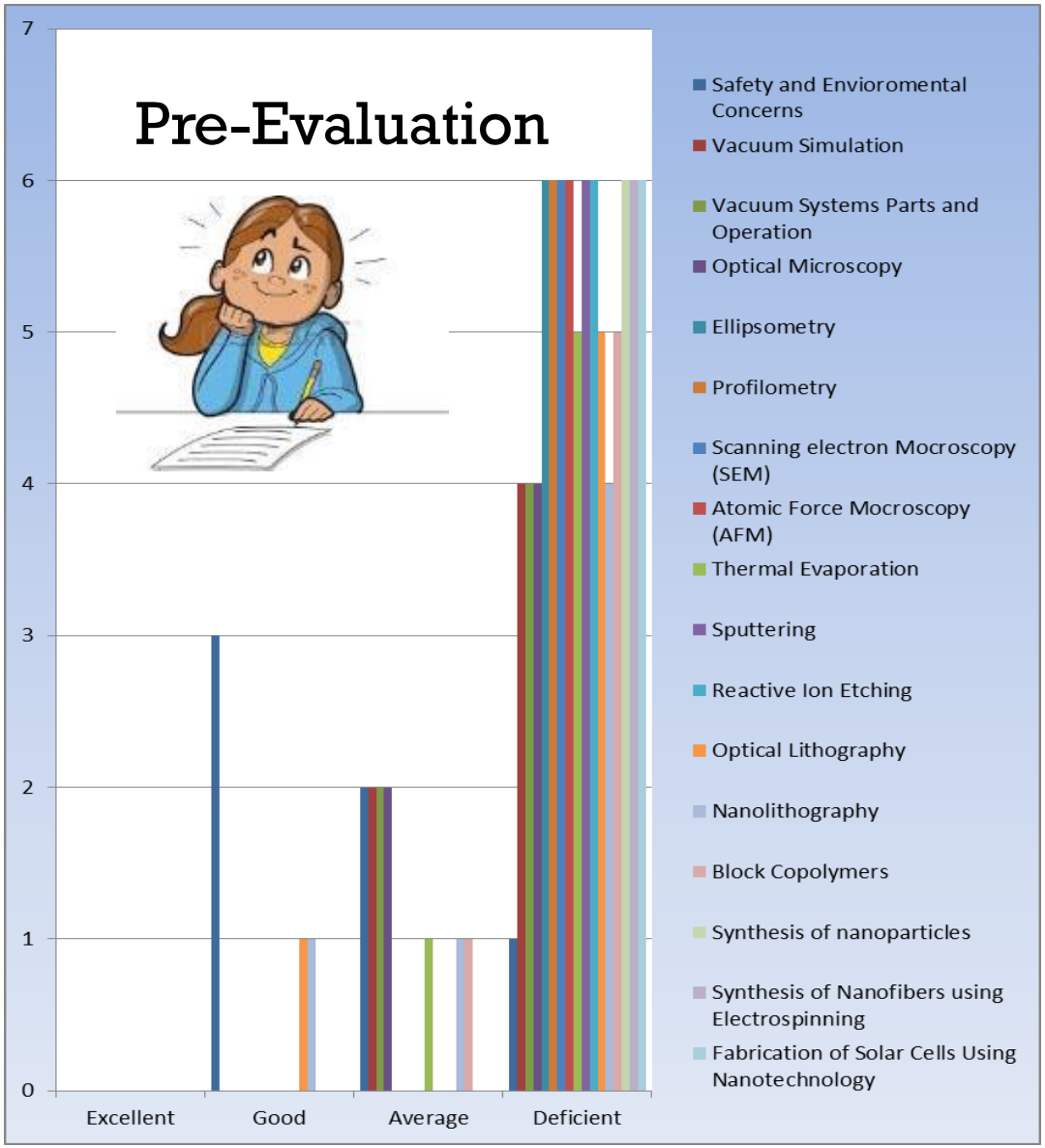


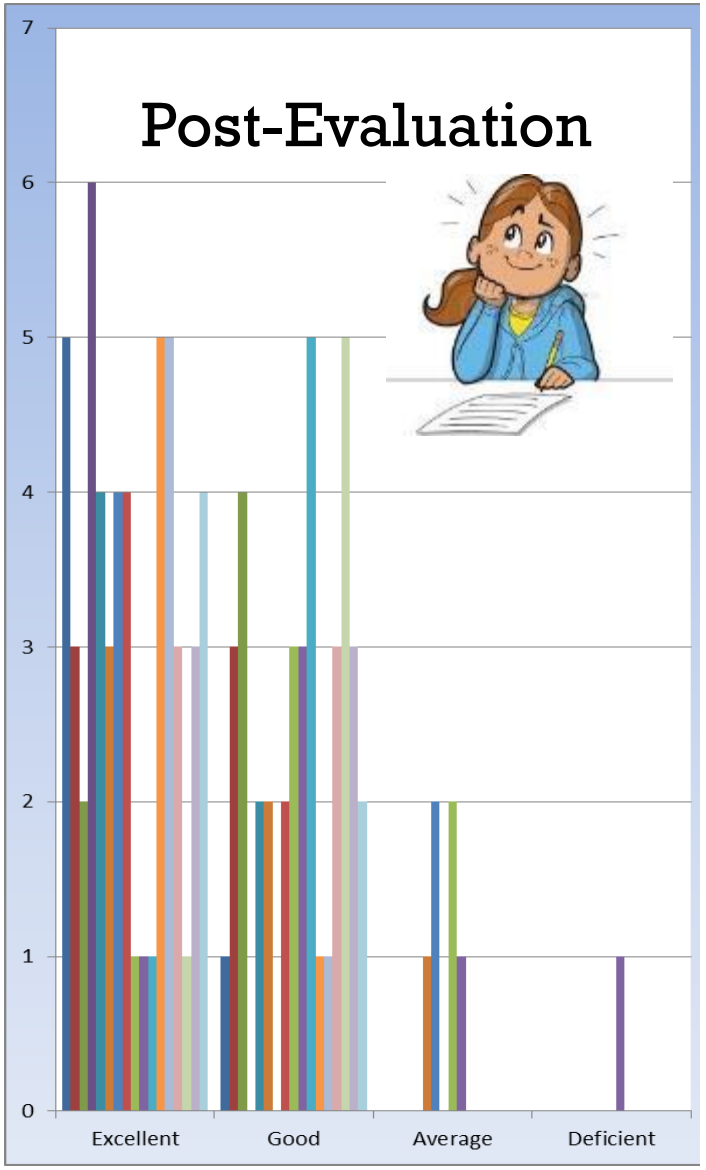


Cohort 2014 – sample of 6

Images:schoolclipart.biz;
blogs.baruch.cuny.educampus.com
cherrycreekschools.org

Pre/Post Evaluation Results Continued





Cohort 2014 – sample of 6

Student Survey – Industrial Nanotechnology Lab and Theory

Questions		Range	Number of Answers
a	I would rate the lecture sessions.	0 (Low)	
		1	
		2	
		3	
		4	2
		5 (High)	4
b	I would rate the lab sessions.	0 (Low)	
		1	
		2	
		3	
		4	1
		5 (High)	5
c	The lecture sessions scheduled allowed time for learning the subject matter.	yes	6
		no if no, please comment	
		No answer	
d	The laboratory sessions scheduled provided adequate time for developing nanotechnology-processing skills.	yes	6
		no if no, please comment	

Student Survey – Industrial Nanotechnology Lab and Theory

e	**The lecture instructors were well prepared for class.**	**yes**	**6**
		no if no, please comment	
f	The laboratory instructors were well prepared for class.	yes	6
		no if no, please comment	
g	The pace of the workshop was…	Too slow	1
		About right	5
		Too fast	
h	The methods of evaluating student work were fair and appropriate.	yes	6
		no if no, please comment	
i	The instructors provided opportunities for students to demonstrate their abilities.	yes	6
		no if no, please comment	
j	The required readings were valuable.	yes	6
		no if no, please comment	
k	The students were encouraged to participate in class discussions.	yes	6
		no if no, please comment	

Student Survey – Industrial Nanotechnology Lab and Theory

l	**The instructors made students feel welcome in seeking help/advice in or outside class.**	**yes**	**6**
		no if no, please comment	
m	The feedback on examinations and graded material was valuable.	yes	6
		no if no, please comment	
n	The instructors achieved objectives of the courses.	yes	6
		no if no, please comment	
o	The instructors met classes, labs, etc. regularly.	yes	6
		no if no, please comment	
p	I have learned the subject materials and developed the skills presented in the workshop:	yes	6
		no if no, please comment	
q	My enthusiasm for learning during the courses was:	Very high	2
		High	4
		Average	
		Low	
		Very Low	
		No answer	
Comments:			
1	An experience very pleasant, since I've learned new and innovating things.		
2	Honestly it was a good class.		

Lessons Learned and Conclusions

- Proof of Concept from NACK Workshops course delivery (workshops, training at Penn State, access to instructional materials) *facilitated* implementation of nanotech courses
- Nanotech courses have been recognized as a valuable asset by the university's administration, by the Associate Degree Program's Advisory Board (which includes members from local companies) and by ABET (during recent site visit)
- Student evaluations and comments of the course were very positive
- We hope the nanotech courses will continue to impact recruitment and retention (this will be measured next year)

Questions?

Please type your questions in the chat box

- UPRH's Physics and Electronics Department is a member since 2008

Visit US! (https://sites.google.com/site/nackupr)

Dr. Josee Vedrine-Pauléus (josee.vedrine@upr.edu),
Dr. Luis G. Rosa (luis.rosa13@upr.edu), and
Dr. Rogerio Furlan (rogerio.furlan@upr.edu)
nackuprh@gmail.com

(Thanks to Melanie Perez, Ruby Melendez, Marlene Bazan for their supporting roles)

How Can We Better Serve You?

Whether you are joining us live or watching the recorded version of this webinar, please take 1 minute to provide your feedback and suggestions.

Survey link

Webinar Recordings

To access this recording, slides, and handout visit

nano4me.org/webinars.php

Certificate of Participation

If you attended the live version of this 1.5 hour webinar and would like a certificate of participation, please email:

sbarger@engr.psu.edu

2015 Events Calendar

March 27, 2015 *Webinar*	Nanotechnology, Energy, into Energy Storage
April 24, 2015 *Webinar*	Self-Assembled Monolayers
April 13 – 16, 2015 *Workshop*	Nanotechnology Course Resources I: Safety, Processing, and Applications
May 12 – 14, 2015 *Workshop*	Hands-On Introduction to Nanotechnology for Educators

Want more events? Visit www.nano4me.org/webinars for more details about these and other upcoming workshops and webinars in 2015.