2023 ATE PRINCIPAL INVESTIGATORS' CONFERENCE
OCTOBER 25-27

High Impact Workshop:

STEM Education across Diverse Student Population including Veterans

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PennState College of Engineering | CENTER FOR NANOTECHNOLOGY EDUCATION AND UTILIZATION

MNT-EC Micro Nano Technology Education Center

NORMANDALE COMMUNITY COLLEGE

High Impact Workshop:
STEM Education Across Diverse Student Population Including Veterans

Date: Wednesday, October 25, Time: 1:00 – 2:50 p.m., Room: Hampton

	Time (EST)	Presentation Topic or Activity	Presenters/Facilitators
1	1:00-1:10 pm	Welcome to the Workshop	Zachary Gray, Vishal Saravade
2	1:10-1:40 pm	Microelectronics and Nanotechnology Education across Diverse Students	Vishal Saravade, Zachary Gray
3	1:40-2:10 pm	Microelectronics and Nanotechnology Education Curriculum Resources	Billie Copley, Zachary Gray
4	2:10-2:40 pm	Remote Access for Hands-on Lab Experience	Nancy Louwagie, Thomas Johnson, Vishal Saravade
5	2:40-2:50 pm	Wrap-up and Open Discussion	Led by Vishal Saravade, Zachary Gray

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Insights into Microelectronics and Nanotechnology Education across Diverse Student Populations through a Veterans Program

- Zachary Gray and Vishal Saravade

Center for Nanotechnology Education and Utilization,
Pennsylvania State University

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OCTOBER 25-27

NSF

PennState College of Engineering

CENTER FOR NANOTECHNOLOGY EDUCATION AND UTILIZATION

Presenters

Zachary Gray

Managing Director

Vishal Saravade

Assistant Teaching Professor

CNEU Team

Osama Awadelkarim
Director and UNESCO Chair Professor

Sue Barger
Administrative Support Coordinator

Zachary Gray
Managing Director

Renee Lindenberg
Support Assistant

Vishal Saravade
Assistant Teaching Professor

Bob Ehrmann
Part-time Education Program Specialist

Content

- **Introduction and Motivation**
- Microelectronics and Nanomanufacturing Certificate Program (MNCP)
- Insights from the MNCP Program
- Conclusions and Future Outlook

Microelectronics and Nano programs

- Existing Microelectronics and Nano programs in general
  - Usually part of multiple-year higher education degree programs
  - Educate the students broadly about the fields with some industry focus
  - Generally focused on graduate students
  - Valuable in introducing students to the areas of micro and nanotechnology

- Challenges
  - Scaling education across diverse students in the class
  - Goal would be focused on workforce development in micro and nanotechnology
  - In the case of veterans, leverage their skills developed through military experience in the micro and nanotechnology industries

Microelectronics and Nano programs for Veterans

Need to scale up existing microelectronics and nanotechnology programs specifically for diverse student population including veterans

Programs like

CENTER FOR NANOTECHNOLOGY EDUCATION AND UTILIZATION

The Nanofabrication Manufacturing Technology (NMT) Partnership

Master of Science (M.S.) in Engineering at the Nano-scale

+

Skillset - I

- Microelectronics
- Nanotechnology
- Materials
- Semiconductors Processing and Packaging
- Cleanroom

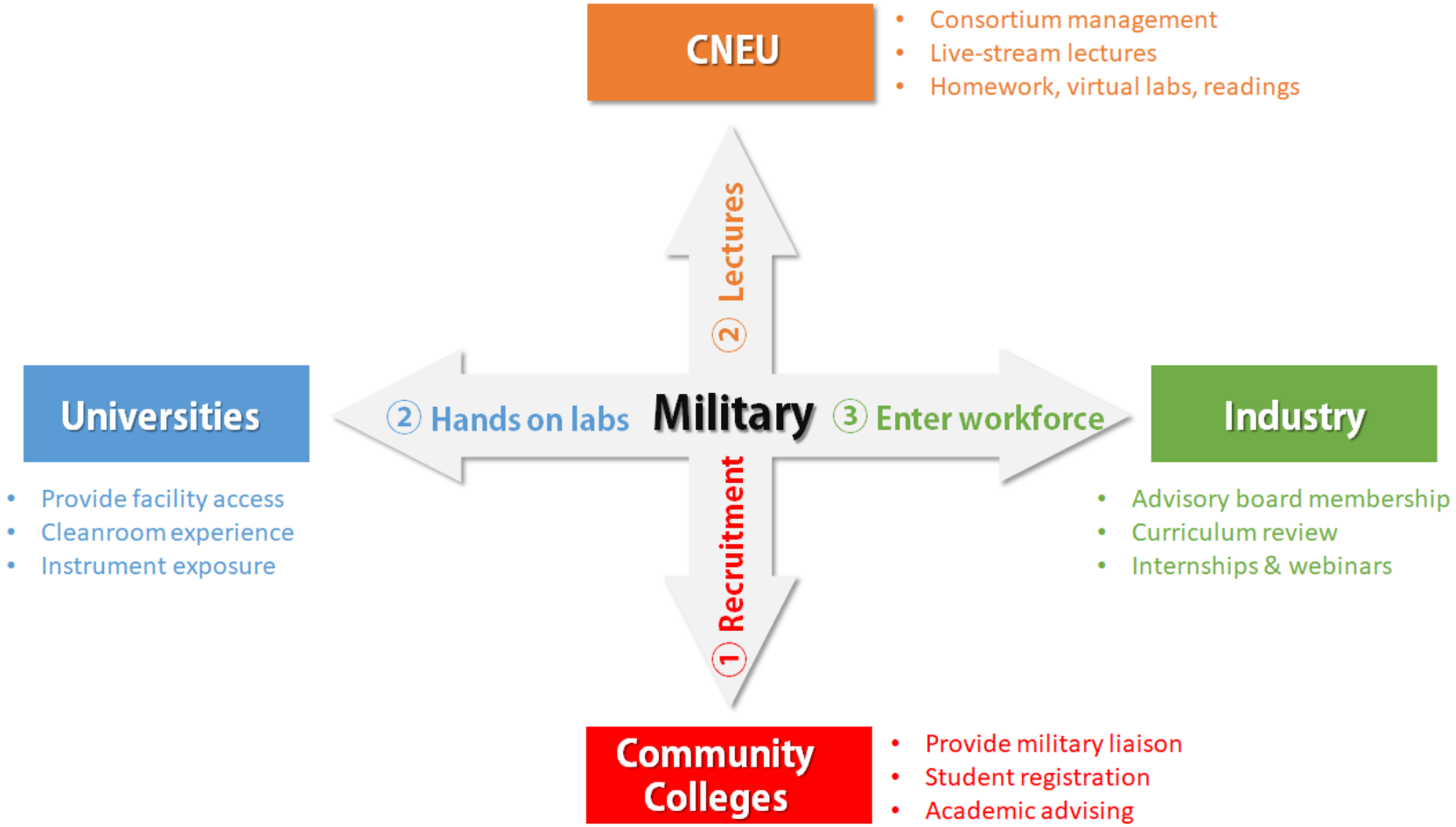
Skillset - II

- Discipline
- Troubleshooting
- Problem-Solving
- Critical Thinking
- Teamwork
- Decision-making
- Time-Management

Content

- Introduction and Motivation
- **Microelectronics and Nanomanufacturing Certificate Program (MNCP)**
- Insights from the MNCP Program, and Plans for the Next Cohort
- Conclusions and Future Outlook

Microelectronics and Nanomanufacturing Certificate Program

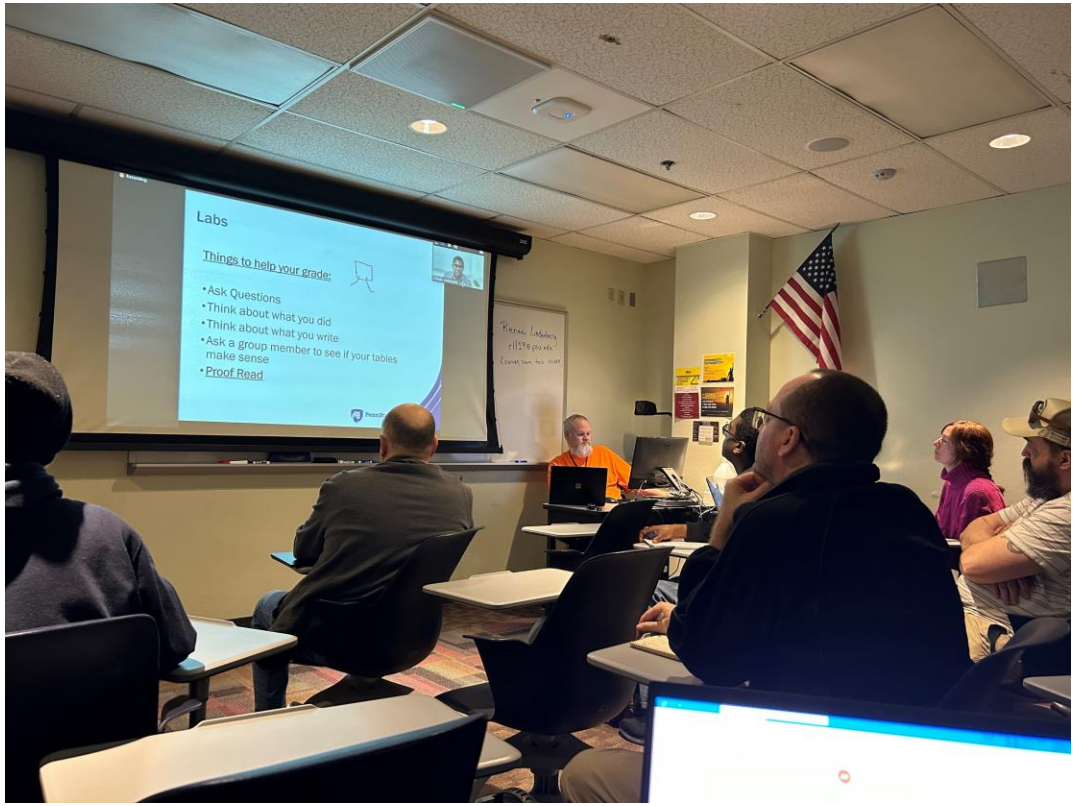


Institutions Involved:

- Penn State CNEU
- Rio Salado Community College
- Arizona State University
- Southwestern Community College
- University of California San Diego
- Tidewater Community College
- Norfolk State
- Georgia Piedmont Community College
- Georgia Tech
- Plan to expand!

Microelectronics and Nanomanufacturing Certificate Program

California cohort in lab



Arizona cohort in lecture

Microelectronics and Nanomanufacturing Certificate Program

Curriculum Overview

1. Health and Safety in microelectronics and nanotechnology labs
2. Vacuum and accessories
3. Materials – Metals, semiconductors, dielectric/insulators, polymers
4. Nanomaterials
5. Oxidation, and metallization
6. Material deposition (Evaporation, Sputtering, CVD, PVD, etc.)
7. Materials characterization (XRD, SEM, AFM, Ellipsometer, etc.)
8. Integrated circuit chip processing
9. Photolithography and other lithography techniques
10. Etching
11. Semiconductor devices and processing
12. Devices characterization
13. Chip manufacturing, assembly and packaging

Microelectronics and Nanomanufacturing Certificate Program

Lectures

- Learning newer concepts and techniques - depth & breadth
- Understanding of technical concepts
- Brainstorming for problem-solving

Hands-on Labs

- Intensive cleanroom experience
- Hands-on experience on equipment and processing
- Technical writing skills (technical reports, standard operating procedure (SOP), etc.)

Quizzes (Mini-exams)

- Retainment of knowledge
- Cross-applications of knowledge obtained
- Emphasizing on most important topics/concept

Homeworks

- Ability to understand and apply skills to address technical questions
- Technical reading skills
- Sometimes application of simple calculations for process designs

Virtual Labs

- Skills to understand SOP and newer equipment, and answering related questions
- Emulation of Hands-on-like labs

Project

- Independent study of a topic
- Presentation and team management/ inter-personnel skills
- Confidence to work in the micro and nano area

Content

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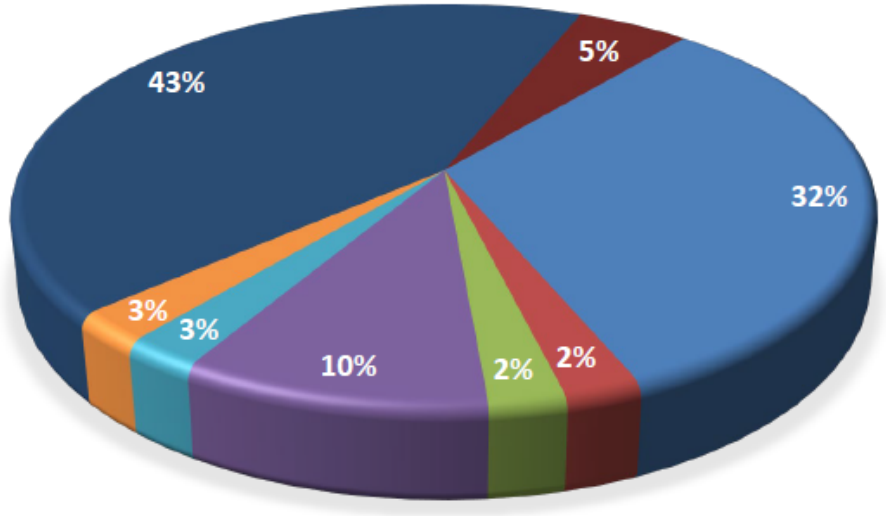
Insights from MNCP – Recruitment (From Student Survey)

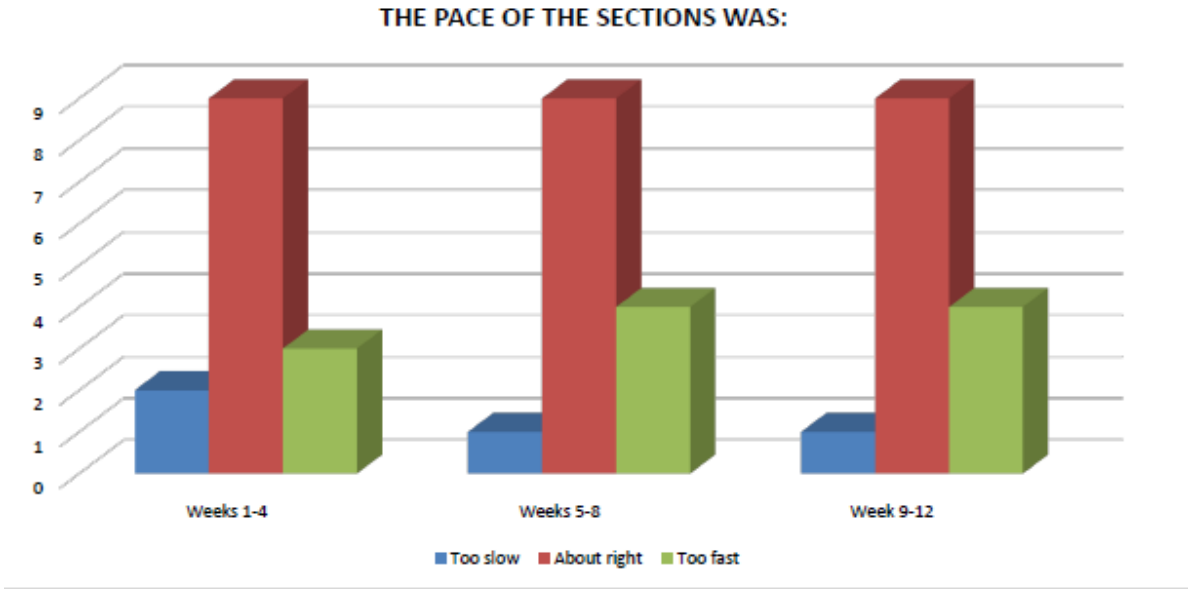
WHICH OF THE FOLLOWING REASONS WERE IMPORTANT TO YOU WHEN YOU INITIALLY ENROLLED IN THE MNCP? (MARK ALL THAT APPLY)



- Being introduced to companies that were interested in hiring from the program
- career after the military not dealing with the military
- Free to me and I would get paid for it.
- Improve my skills for the job that I held prior to attending the Course
- it is very interesting and i like improving my skill set
- Learn a new skill and better understanding
- Learn skills needed to enter the job market in nanotechnology manufacturing immediately after attending the MNCPNCP
- Prepare for transfer to a four-year college or university

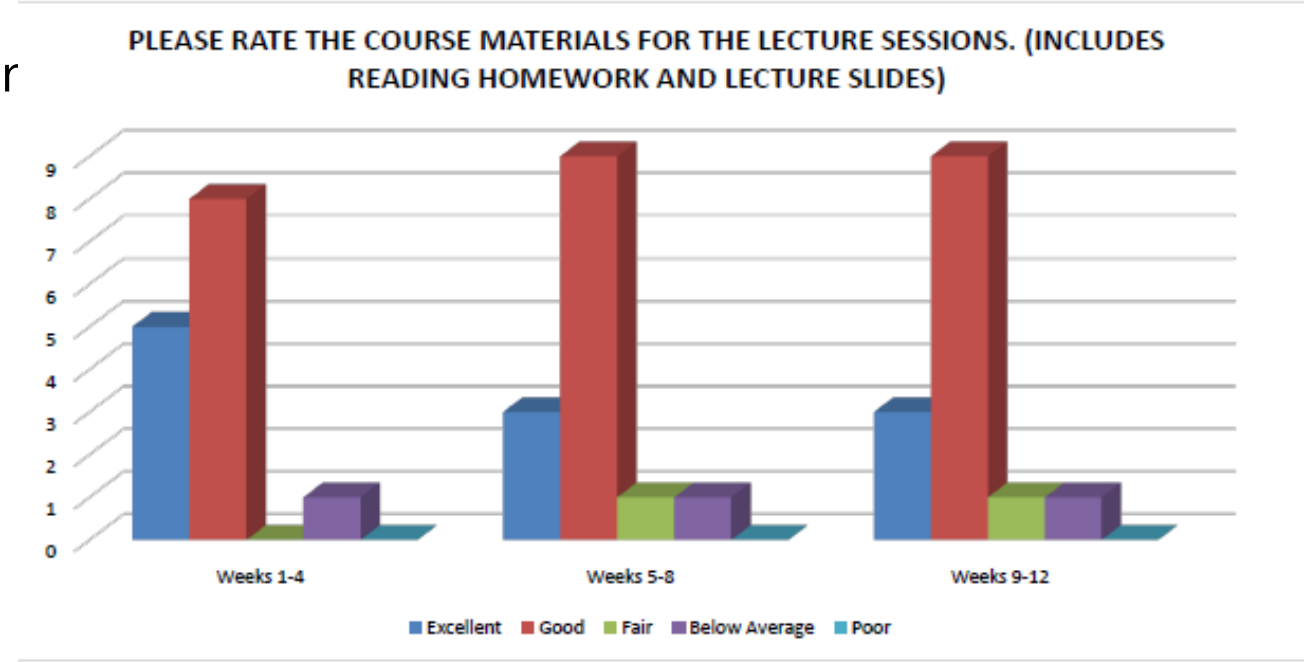
Insights from MNCP - Lectures

- ❑ Lectures
  - Relatable to real-life examples around
  - Revisiting important questions
  - Flexibility as required
  - Interactive
- ❑ Pace of the lectures
  - Keep the content challenging and interesting
  - Prevent attrition
  - **Slower lectures - Students did not complain**
  - Faster lectures
    - At the beginning – Students find it difficult
    - Towards the end – Students can handle
- ❑ Insights and Outlook
  - Keep lectures to the point and topics
  - Keep flexibility in pace
  - Refer to lab colleagues for lab questions



Insights from MNCP - Homeworks

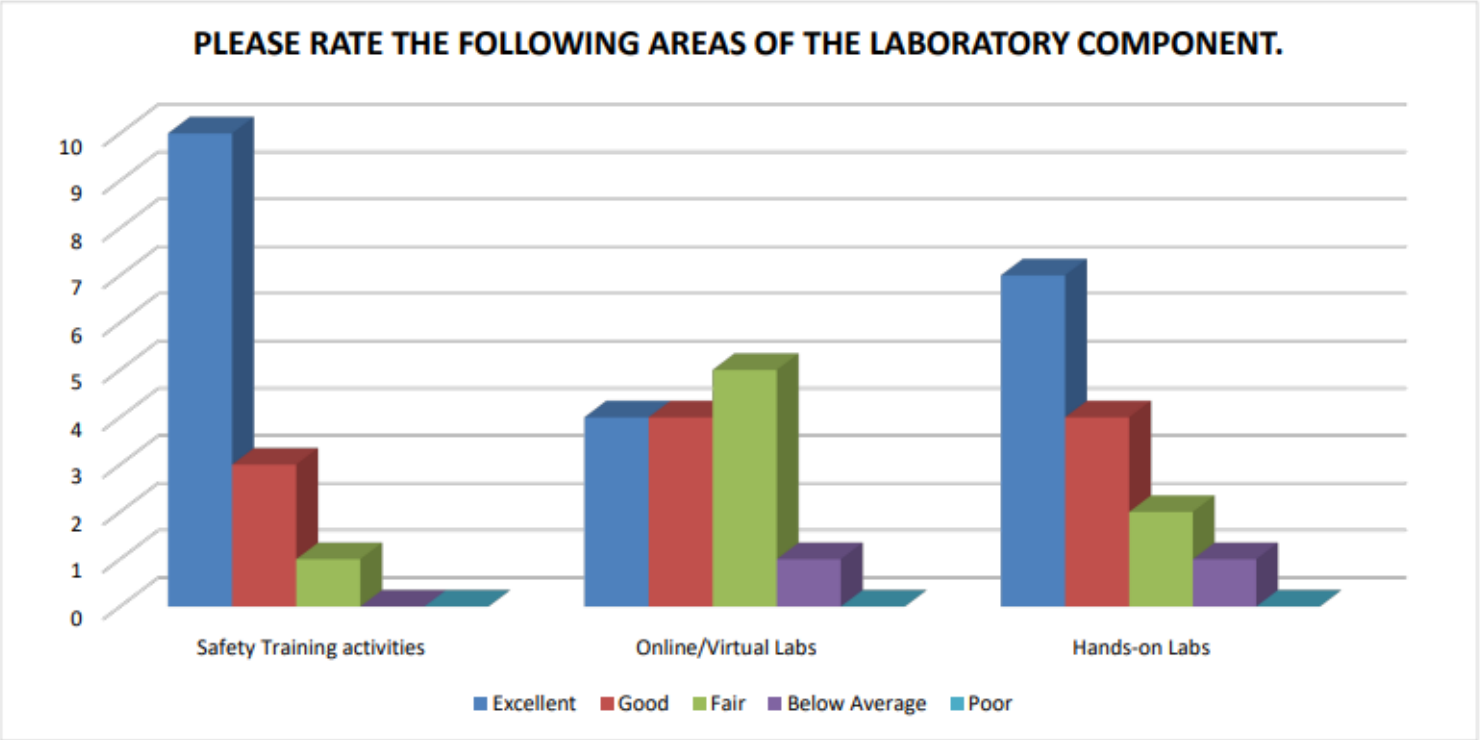
- ❑ Reading and Homeworks
  - Crucial to familiarize the students with jargor in microelectronics and nanotechnology
  - Handling mathematical equation
  - Wording of the questions
- ❑ Insights and Outlook
  - Improve wordings of questions
  - Reduce grey-area questions
  - Encourage students to ask for clarity if they find it difficult interpreting the question



Insights from MNCP - Labs

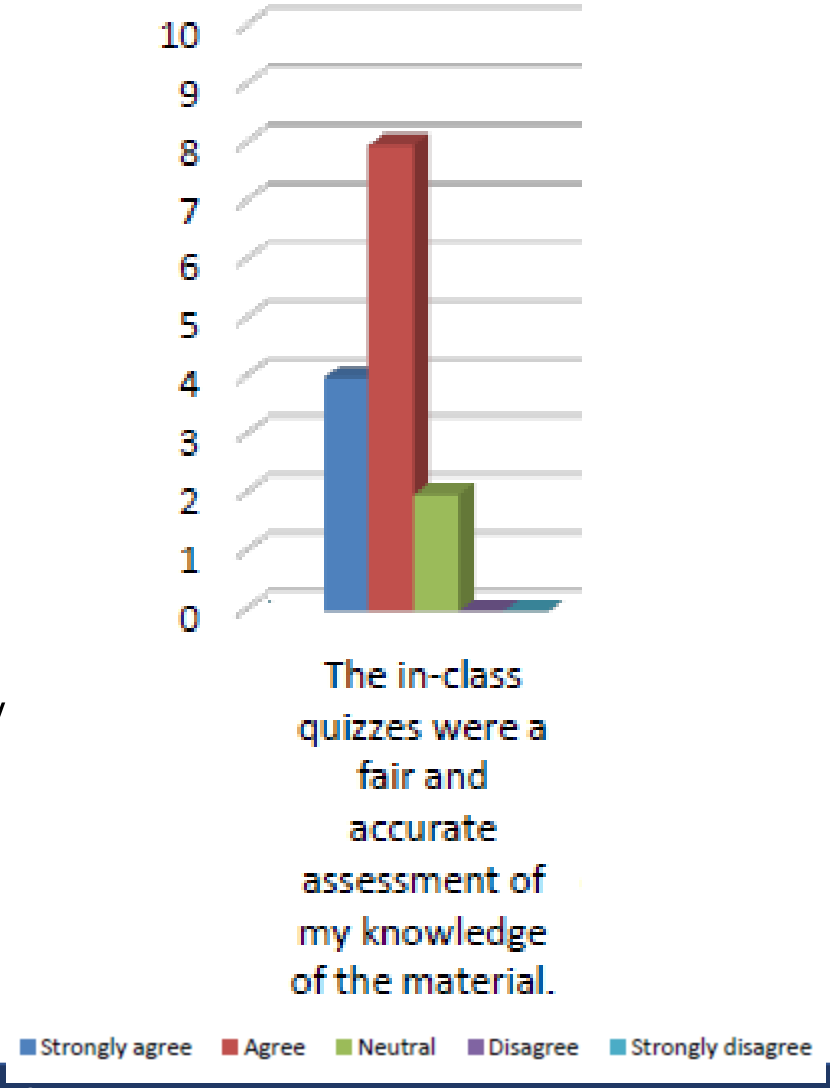
- Learnings from labs
  - Common trend was students wanted more hands-on time than they got. Most students stated "they learn best hands-on"
  - Some students claimed using virtual labs confused them more than it helped them

- Insights and Outlook
  - Optimize lab times – not to overwhelm but be satisfactory
  - Briefly review concepts before the lab
  - Grade in 1-2 weeks preferably



Insights from MNCP - Quizzes

- In-class quizzes
  - Once every 1-3 weeks
  - Total of 5-6 quizzes in 12 weeks
  - Targeted difficulty level – Prepare students for ASTM exams
  - Students did fairly good in the quizzes
  - Data-based decisions on difficulty levels
- Insights and Outlook
  - Encourage students not to rush
  - Some questions would had been answered correctly had they been read more carefully
  - Improve wordings of the questions
  - Reduce grey-area questions
  - Tune the difficulty levels based on students performance



Insights from MNCP - Projects

- Projects
  - Inquiry-based projects
  - Increased confidence to handle a relatively newer topic (students were nervous when the projects were assigned)
  - Ability to find new information independently and with limited teaching from the instructors on their topics
  - Project update meetings every 1-3 weeks (informally)
  - Excellent teamwork
  - Fluency with the microelectronics/nanotechnology jargon
  - High quality presentations
- Insights and Outlook
  - Individual student project instead of group project
  - Scheduled systematic project updates in the lecture

Project Presentations Schedule

	Group #	Project Topic	Time of Presentation	
1	AZ-1	CMOS Technology Nodes	April 25 (Tuesday)	11 am EST
2	AZ-2	GaN and Applications		noon EST
3	CA-1	2-Dimensional Semiconductors	April 26 (Wednesday)	11 am EST
4	CA-2	GaAs and Packaging		noon EST
5	GA	Silicon Photonics	April 27 (Thursday)	11 am EST
6	VA	SiC and C Allotropes		noon EST

Project Presentations Grading

Criteria	Grading Percentage (Tentative)
Instructors and TA evaluations	50%
Class-peer evaluations	30%
Inter-team peer evaluations	20%

Insights from MNCP - Industry

- ❑ <u>What did industry do for students?</u>
  - Most gave ~1 hour company overview via Zoom
  - Some gave tours
  - Some focused on veteran resources
  - Some gave resume templating advice
  - Several students already hired or in interview process

- ❑ <u>Insights and Outlook</u>
  - Add small and medium size companies
  - Aiming for weekly industry talks on Fridays

We need to continue tracking past students and their industry interactions

Additional companies we'd like to add: Edwards Vacuum, KLA, Absolics

MNCP Program Insights Summary

Lectures

- Keep lectures to the point and to the specific topic for the day
- Don't over-teach concepts
- Keep flexibility in lecture pace
- Refer to appropriate colleagues for lab-related questions

Hands-on Labs

- Optimize lab times so that students are not overwhelmed, but also satisfied with the labs
- Very briefly review the concept covered in the lab during or a few minutes before the lab
- Grading in ~1-2 weeks after lab

Quizzes (Mini-exams)

- Improve questions-wordings
- Encourage students not to rush and read questions completely
- Gauge and tune the difficulty level based on the students performance

Homeworks

- Improve questions wordings
- Reduce grey-area questions
- Encourage students to ask for clarity if they do not understand the question

Virtual Labs

- Encourage students to watch the videos completely
- Clarify that this is different from hands-on labs
- Improve questions wordings
- Reduce grey-area questions

Project

- Considering option of individual student projects
- Project topic could be assigned by instructors or suggested by students

Content

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- **Conclusions and Future Outlook**

Conclusions and Future Outlook

Conclusions

- Crucial to scale teaching methods as per the diversity of students in the class
- Pace and challenges → Keep students interested enough, but not discouraged
- Difficulty levels as per the diversity of the class
- Comfortability with handling complicated microelectronics and nanotechnology equipment
- Comfortability with cleanrooms

Future Outlook

- Extending the experiences to general students classes
- Clarity of program level, time commitments, and pre-requisites
- Clarifying the primary purpose of the program for the students
- Enhancing the application process with interviews can assist in these clarifications

Questions?

Come, See us at...

ATE Connects Session: **Session 2 – Thursday, October 26 from 3:45 – 5:30 p.m.**
Hub Number: S2-605
Discipline: Micro and Nano Technologies

NACK CENTER

REMOTE ACCESS INSTRUMENTS FOR NANOTECHNOLOGY
RAIN

High Impact Workshop:
STEM Education Across Diverse Student Population Including Veterans

Date: Wednesday, October 25, Time: 1:00 – 2:50 p.m., Room: Hampton

- Scaling education across diverse students
- **Challenges with curriculum development especially for early educators**
- **Need for teaching materials for colleges starting micro and nano technology programs**
- **Micro and Nano technology Curriculum Development**

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MNT-EC Curriculum Development

- Billie Copley – Center Manager
- billie@micronanoeducation.org

MNT-EC

Micro Nano Technology Education Center

Looking to add nanotechnology curriculum to your classes?

Introducing MNT-EC's Intro to Nanotechnology course!

- Modules include:
  - sense of scale
  - material properties
  - scanning electron and atomic force microscopy
  - bottom-up synthesis
  - top-down nanofabrication.

Modular Structure and Focus Areas

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Content includes the principles of nanoscale materials, nanofabrication processes like lithography and etching, and various characterization techniques like electron microscopy and spectroscopy.

Each module is carefully structured to ensure a seamless progression of knowledge from basic concepts to more advanced applications,

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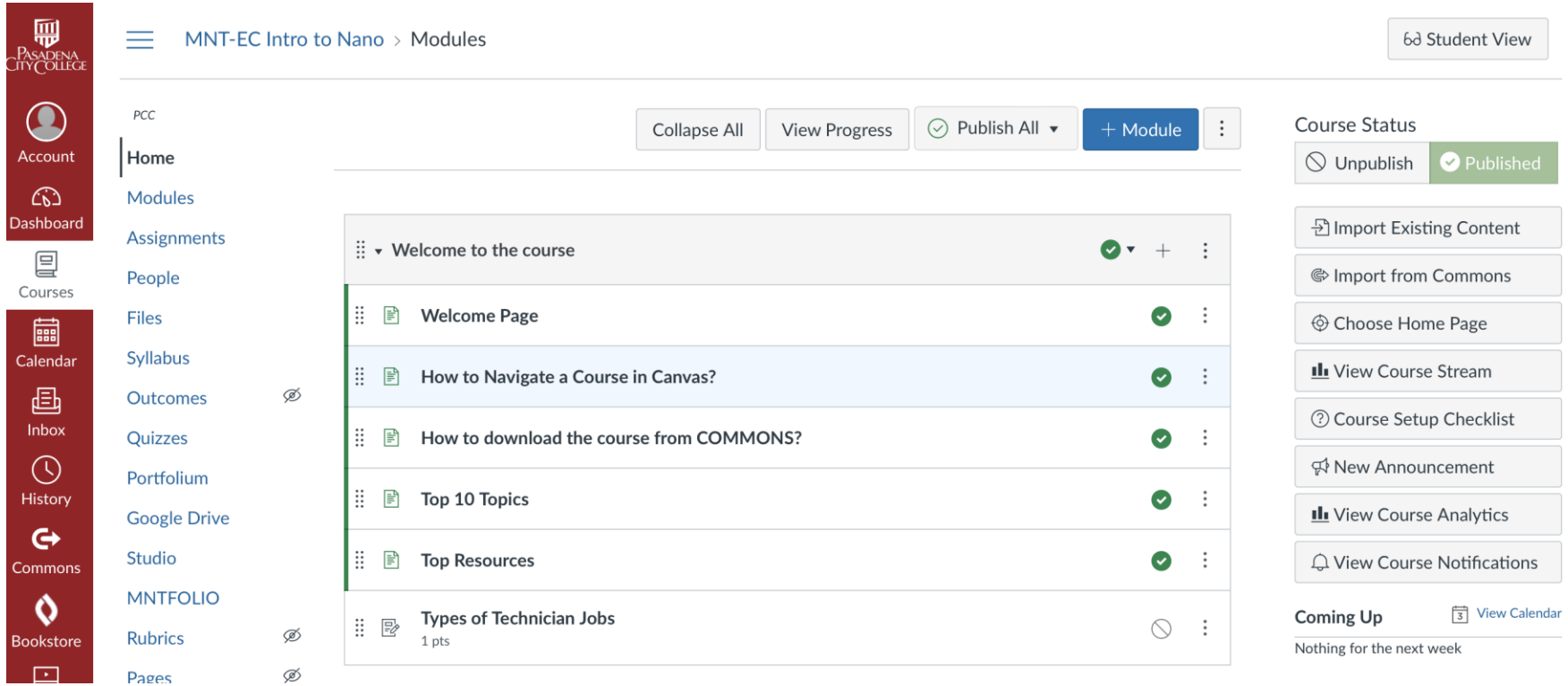
Micro Nano Technology Education Center



Significance of a Comprehensive Curriculum

- Comprehensive curriculum with 10 Introduction modules
- Bridge the gap between theoretical knowledge and practical application

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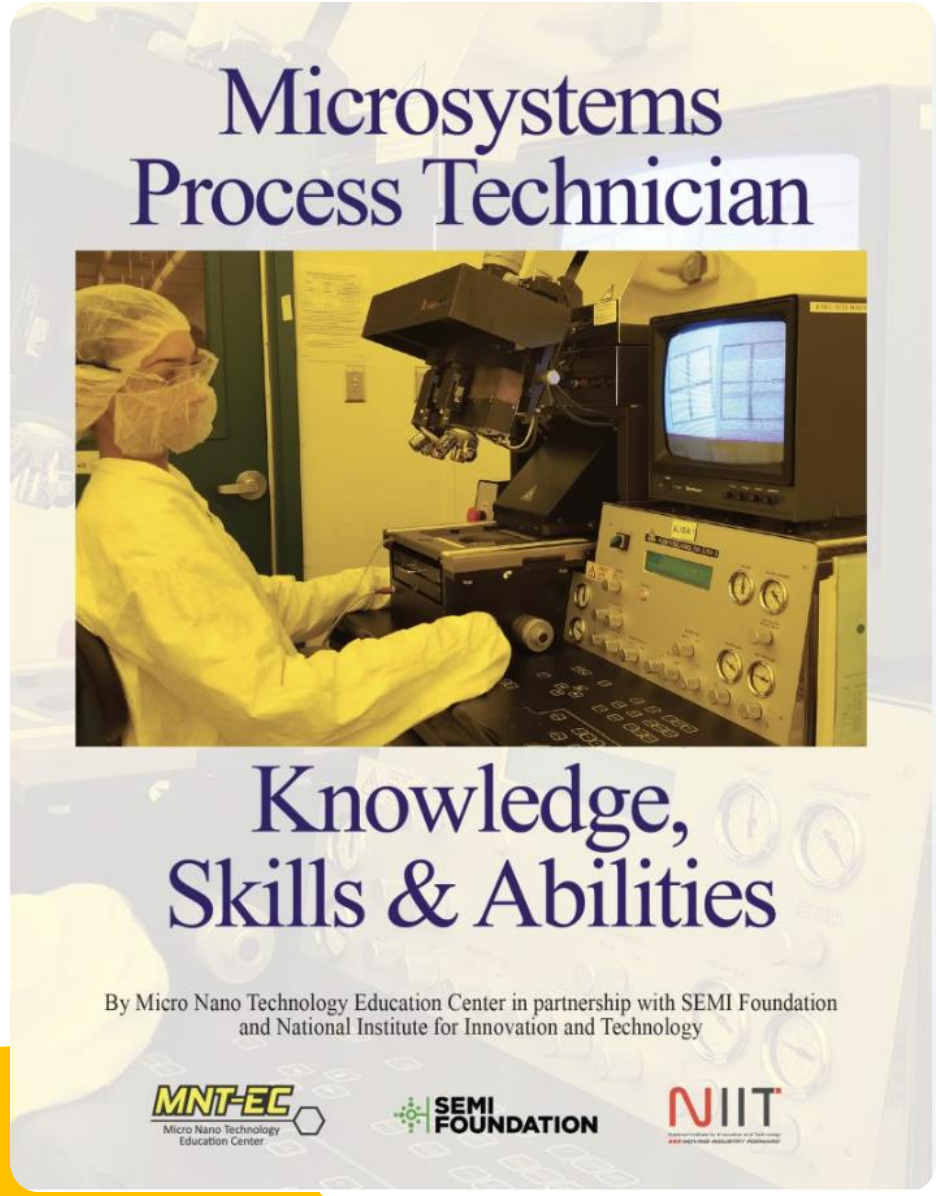
Enhanced Accessibility and Inclusivity

- Working closely with the CAST team to improve accessibility functions

How to Access

Canvas Commons –

- Log into your canvas account on the Canvas website or through your institution.
- Search for Intro to Nano
- Download files and import into your canvas classroom.
  - Can be imported into other LMS as well like Blackboard, Moodle, and D2L Brightspace.
  - Instructions can be found here: https://micronanoeducation.org/intro-to-nanotechnology-course/



Industry Collaboration and Practical Relevance

KSA are developed from the partnerships with industry leaders and organizations that have contributed to the practical relevance of the curriculum

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- Scaling education across diverse students
- Challenges with curriculum development especially for early educators
- Need for teaching materials for colleges starting micro and nano technology programs
- Micro and Nano technology Curriculum Development
- **Challenges with accessing micro and nanotechnology equipment**
- **Need for abilities to access educational equipment remotely**
- **Remote Access for Hands-on Labs Experience**

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Enhancing Student Learning Experiences through NSF-ATE Partnerships

REMOTE ACCESS FOR HANDS-ON LAB EXPERIENCE

This work was made possible in part by grants from the **National Science Foundation** (ATE DUE #1400408, #1700624, #2000454, #2202166)

Introductions

- Nancy Louwagie
  - Instructor in Vacuum and Thin Film Technology at Normandale Community College (Bloomington, MN)
  - PI, NSF-ATE DUE #2202166
- Tom Johnson
  - Instructor in Vacuum and Thin Film Technology at Normandale
  - Co-PI, NSF-ATE DUE #2202166

Overview

- Normandale's Vacuum and Thin Film Technology program has benefitted from a series of NSF-ATE project awards. One distinct benefit is the opportunity to collaborate with and learn from other NSF-ATE projects and NSF-ATE Centers.
- We'll discuss how these partnerships impacted Normandale's series of ATE projects and benefitted partners and students.
- We'll demonstrate how Normandale and the Center for Nanotechnology and Utilization (CNEU) at Penn State collaborate to support veterans participating in the Microelectronics and Nanomanufacturing Veterans Partnership (MNVP) program.

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NSF-ATE DUE Projects at Normandale

Plasma Technology

Vacuum Technology

#0603365	#1400408	#1700624	#2000454	#2202166
• Curriculum • Equipment	• Course curriculum • Equipment Trainers • Distance Ed delivery	• Gateway course • Credential curriculum • Remote access equipment • UREs	• Ebook • Hands-on learning • Professional Development	• Automation • Modular courses • Student support services
○ Portland CC	○ Mohawk Valley CC ○ UW Stout	○ NACK (RAIN) ○ ASU (SEM) ○ Erie CC (VACT) ○ Erie CC (SEM)	○ Erie CC ○ NACK/CNEU ○ MNT-EC ○ Hudson Valley CC	○ Erie CC, Rio Salado, Pasadena CC, MATC ○ NACK/CNEU ○ MNT-EC

PARTNERS

Impacts of Collaboration

- DUE #0603365

  Normandale's first NSF-ATE project. A former instructor and NSF-ATE PI at Portland CC served as co-PI. Designed and built physical vapor deposition systems to support classroom instruction/demonstrations.

- DUE #1400408

  Designed and built high vacuum equipment trainer (VET) systems for hands-on learning. Shipped VET systems to partners with student co-horts. Delivered distance education classes in a video conferencing format that incorporated onsite use of the VET systems (Erie CC).

Impacts of Collaboration (cont.)

- DUE #1700624
  - Normandale utilized SEMs at AZ State University (ASU) and Erie CC through the NACK ATE Center (AC) Remotely Accessible Instrumentation for Nanotechnology (RAIN) network to support classroom instruction.
  - Modified a project deliverable from developing another shippable VET system to acquiring a remotely accessible deposition system; also upgraded a profilometer tool for remote access capabilities.
  - Applied for and received supplemental funding for UREs based on SCME AC and MNT-EC AC / Pasadena CC experiences. Engaged URE students in re-designing VETs with remote access capabilities.

Impacts of Collaboration (cont.)

- DUE #2000454
  - Normandale served as a sub-awardee on Erie CC's first NSF-ATE project award. Developed Ebook, hands-on learning labs and instructor manual resources for vacuum technology instruction. These resources have been used/tested by program students / participants at Hudson Valley CC and in CNEU's MNVP program. MNT-EC makes these resources available through their website.

Impacts of Collaboration (cont.)

- DUE #2202166
  - Re-designed curriculum into a modular course structure for delivery in distance education formats. Remotely accessible VET systems provide students with hands-on learning in these modularized courses.
  - Erie CC, project sub-awardee, is adopting the modularized vacuum tech courses and advising Normandale on new automation curriculum.
  - Normandale delivers a short introduction on high vacuum system operation for the CNEU MNVP students / participants.
  - CNEU MNVP students, for example, students at Rio Salado CC enroll in Normandale's distance education vacuum technology classes.

Lessons Learned

Productive ways to partner / collaborate with NSF-ATE projects and NSF-ATE Centers:

- Seek or offer advice on the NSF-ATE project experience,
- Share information and resources,
- Collaborate to test project deliverables,
- Recommend and recruit project participants,
- Provide motivation for future projects,
- Stay connected – attend workshops, participate in activities
- Formalize partnerships (articulation agreement(s), contract)

Questions?

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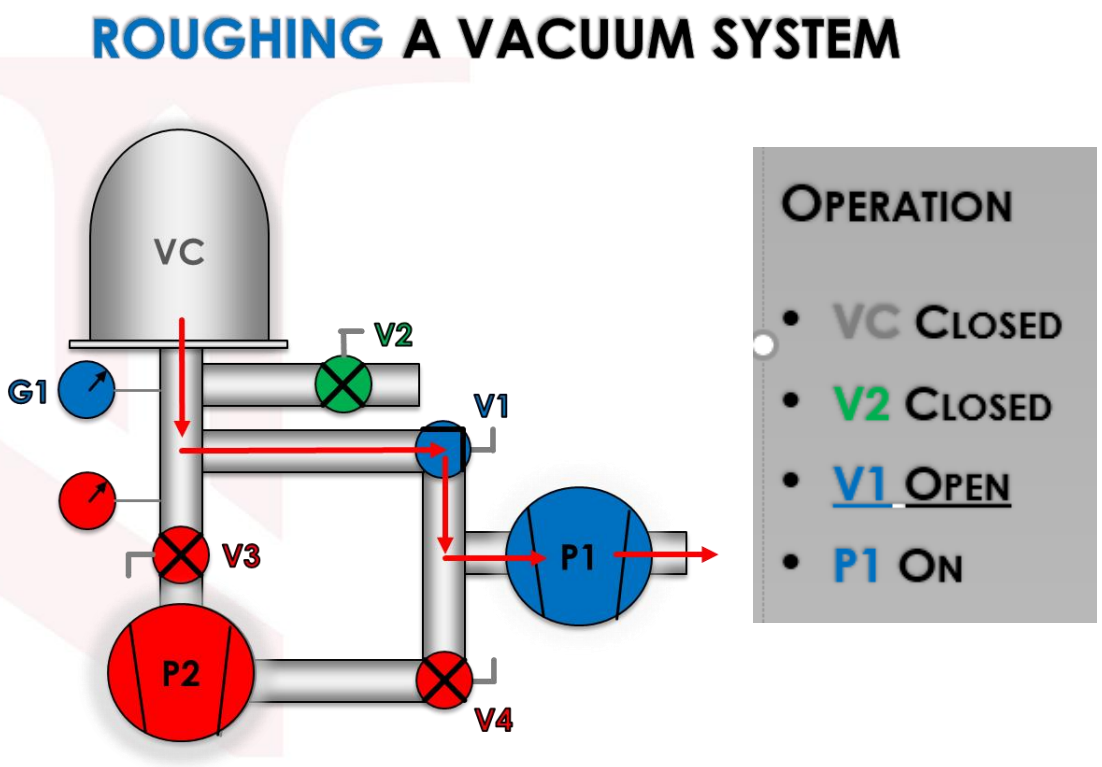
High Vacuum System Operation Workshop for CNEU MNVP Participants

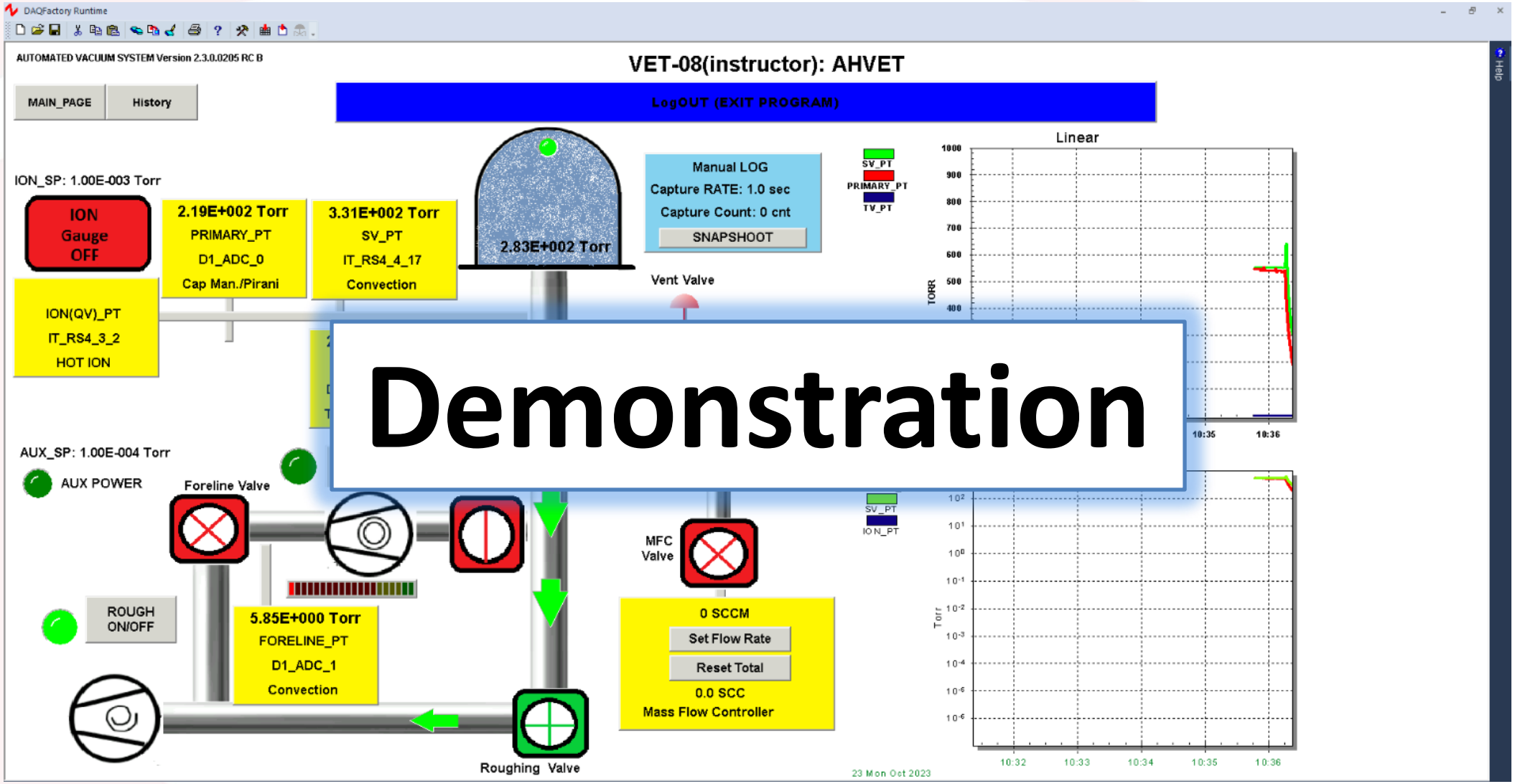
Workshop format

- 90 min – 2 hour session
- Short information pieces (lecture)
- Hands-on practice operating remote access high vacuum equipment trainer system
- Q&A



Workshop Outcomes
Participants will …

- Define vacuum
- Explain why a vacuum condition is important especially in the context of a material deposition process
- Identify significant components present in a high vacuum system
- Perform the sequence of operations using a high vacuum system
- Recognize the basic vacuum system structure in real systems
- Be motivated to pursue further learning in vacuum technology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LogOUT (EXIT PROGRAM)
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Roughing Valve
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23 Mon Oct 2023
Help

Questions?

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Thank You!

Visit us at Hub #S2-602 during Connects Session 2 (Thurs, 10/26, 3:45 – 5:30 pm)

Enhancing Student Learning Experiences through NSF-ATE Partnerships

REMOTE ACCESS FOR HANDS-ON LAB EXPERIENCE

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High Impact Workshop:
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Informal Panel Discussion

1. Solutions for Colleges that do not have many Technical Equipment
2. Low-cost Experiments
3. Industry Relationships
4. Student-recruitment
5. Acceptance Criteria for Students

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THANK YOU !!!

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