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Micro Nano Technology Education Center

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Micro Nano Technology Education Center

Micro Nano Technology (MNT) has been a cornerstone for the National Science Foundation (NSF) Advanced Technological Education (ATE) program. Current and past MNT Centers have contributed distinct programs and resources to the education of micro nano students. Partners whom have led these Centers include:

1) Nanotechnology Applications and Career Knowledge Network (NACK)
2) Support Center for Microsystems Education (SCME)
3) Northeast Advanced Technological Education Center (NEATEC)
4) Nano-Link Center for Nanotechnology Education (Nano-Link)

In collaboration with leadership from these Centers, the *Micro Nano Technology Education Center (MNT-EC)* was established and managed by Pasadena City College, an Aspen Prize for Community College Excellence finalist in 2017 and 2019, along with a leadership team of other community college partners with substantial experience in micro nano technician education and in administration of NSF ATE programs and centers. In total, the leadership team has been awarded and managed twelve ATE grants. Each member was chosen based on their ATE experience and expertise in a distinct MNT discipline, including semiconductor technology, micro-electro-mechanical-systems (MEMS), materials science, photonics, and nanobiology. The MNT-EC establishes a community of MNT educators to define and support technician education in MNT industries.

Issues facing the US MNT industrial and educational community include: 1) low number and lack of diversity among students earning degrees and employment within MNT; 2) lack of faculty mentoring; 3) inconsistent coordination between current programs in developing and sharing educational materials based on industry needs; and 4) shortage and discontinuation of programs that train a competent and diverse MNT workforce.

To address these issues, MNT-EC:

- Creates an infrastructure of educational institutions, industry partners and professional trade associations that evolves MNT education based on emerging technologies.
- Establishes resource sharing among current ATE Centers and Projects in MNT related disciplines.
- Initiates partner mentorship to increase ATE proposal submissions from a more diverse population.
- Optimizes national MNT technician curricula, skills and competencies by incorporating distance education with hands-on training.
- Delivers professional development to increase enrollment and retention, ensuring sustainability of MNT programs, and increasing the quantity of qualified technician workers across the U.S.

The overarching goal of The Micro Nano Technology Education Center (MNT-EC) is to:

> **Grow the micro nano technology (MNT) technician workforce by fostering academic and industry mentorship between existing MNT partners and educators developing prospective community college MNT programs.**

MNT-EC achieves these goals by leveraging existing resources provided by previously-funded NSF ATE Centers: NACK, SCME, NEATEC, SHINE, and Nano-Link while concurrently recruiting and mentoring new MNT community college partners. New partners were chosen for their expertise in distinct micro nano related disciplines, mentoring, or community/industry connections that will expand students' knowledge and opportunities and enhance educational programs. These new partners include: 1) National Resource Center for Materials Technology Education (MatEdU), 2) CAST, 3) Mentor-Connect: Leadership Development and Outreach Initiative for ATE, 4) Midwest Emerging Technologies Public Health and Safety Training (METPHAST), 5) Micro and Nanotechnology Commercialization Education Foundation (MANCEF), 6) Semiconductor Equipment Manufacturing International (SEMI) and 7) nanoHUB. With the proposed partners and collaborators, the MNT-EC is taking a leadership role in advancing education of a skilled technician workforce in micro nano technologies.

Rationale for Micro Nano Technology (MNT) Demand:

When combined, nano and micro technologies together lead to advancement in cross-disciplinary applications (Fig. 1). These applications are a strong driving force of the world's economy[1] and has exerted significant societal impact over a broad range of applications.[2-7] The "internet of things" economically impacts a trillion micro-nano devices, including virtual reality, healthcare and voice processing (Fig. 2).[8] Many important manufacturing applications and materials are influenced by micro nano technology, in areas including energy, composites, filtration and ceramics (Table 1).[9] For example, the atomic force microscope is a MEMS (microsystems) device that images surfaces at the atomic (sub-nanometer) scale. MEMS devices are an approximately $30 billion per year business that expects a 17% compound annual growth rate (CAGR) by 2023[8] and are essential components in accelerometers, sensors, and medical devices. The growth of these emerging technologies requires an increase in the workforce trained in micro nano technologies.

Figure 1 MNT influences nearly all economic sectors and a multitude of applications.

Demonstrating the importance of MNT projects: Although higher education degrees are prevalent within the MNT workforce, Associates degrees and certificates are sparse.[10] Current demand on the MNT workforce cannot be readily met with bachelors' degree recipients. The MNT-EC directly increases the number of community college faculty participating in micro nano technician education, leading to an increase in the number of students who receive technical education degrees and effectively increasing MNT technician workforce participation.

The Economic, Technological and Demographic factors that will influence demand and education paradigms within the MNT workforce over the next twenty years must be addressed.

Field	CAGR	Current Market	Market (Yr)
Energy	12.0%	$5.7B	$10B (2023)
Composites	29.5%	$2B	$7.3B (2022)

Table 1. Applications MNT

Figure 2. Economic Impact MNT applications by 2023

Economic Factors: In 2014, research and development investments and outcomes led to $370 billion in final output from MNT applications in the U. S. (Fig. 3)[6] which grew to ten-fold higher worldwide revenues of MNT-enabled products totaling $3.7 trillion in 2018.[11] Accompanying this steep economic growth is a corresponding need for over one million additional MNT related jobs, the majority of which are technical level positions. Regional technology hubs across the United States, which have been dubbed "Silicon Nation" consist of Silicon Forest (Pacific Northwest), Silicon Valley (Northern California), Silicon Alley (New York), Silicon Cowboys (Texas, New Mexico and Arizona) and Silicon Beach (Florida), are dependent on an MNT workforce for economic prosperity.[12]

Since trained workers with specific industry skills are key to continued economic and technological development, training programs need to evolve and better serve the increasingly diverse range of students entering the workforce. With increasing MNT applications in many markets and a projected workforce shortfall due to retirement of a generation of baby boomer workers, it is vital to have a national focus that forms key partnerships between community college faculty and industry to develop academic opportunities and programs for a broader audience. This is especially true for underrepresented students and women pursuing employment in the MNT workforce. To address this essential need, the MNT-EC has convened a national collaborative to promote technician education pathways that diversify and optimize MNT workforce preparation.

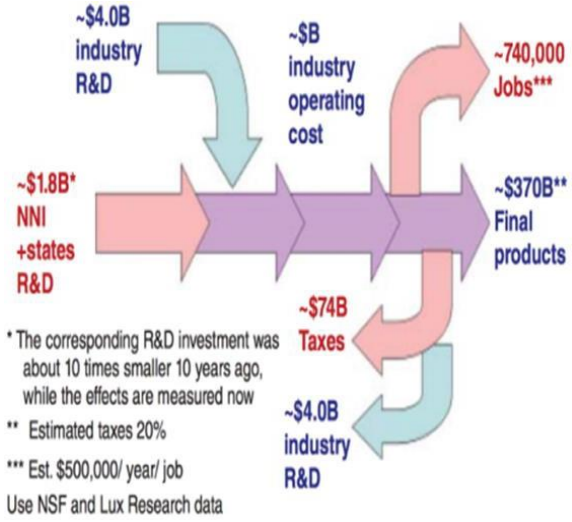

Figure 3. Economic Output of MNT

Technological Factors: Technological factors that influence segments of the MNT industry include the next "node" where chip technology advancement outpaces training and the mechanization of transport and handling of new wafers which will shift technician responsibilities from direct wafer handling into robotic automation maintenance and repair.

Nanotechnology-based diagnostic and therapeutic agents are top emerging technologies in pharmaceutical sciences.[13] Innovations in nanophotonic applications are leading to improved lenses, color printing and hologram devices.[14] These emerging technological factors require that the education paradigm be modernized to meet industry needs. To fulfill these needs, the Micro Nano Technology Education Center is an industry-driven workforce development collaborative consisting of community college, university, non-profit and industry partners that will work together to address these emerging technological factors.

Demographic Factors: The U.S. technician workforce, currently 72% male and 66% white,[15] is changing. As current technicians gray into retirement, there is a growing need to replace these highly trained workers and expand the technician base. Increasing diversity of the MNT workforce must be accomplished by recruiting minorities and promoting technician education to communities throughout the United States.

Community colleges are uniquely positioned to address these demographic factors because of their diverse student populations, large catchment zones and expertise in providing technical and workforce competencies.[16] Strategically placing MNT education programs in areas with diverse community colleges where industry need is high and unique MNT programs, such as in manufacturing, photonics, or biotechnology exist, will maximize the impact of the MNT-EC.

Micro Nano Technology Education Center Outcomes

The overarching goal of The Micro Nano Technology Education Center (MNT-EC) is to: Grow the MNT technician workforce by fostering academic and industry mentorship between existing MNT partners and educators developing prospective community college MNT programs.

This will be done by focusing on four key objectives:

1. Develop coordinated national approach to advance MNT education.
2. Deliver professional development to enhance knowledge, skills, and abilities.
3. Conduct strategic outreach, recruitment and retention of traditional and underrepresented faculty/students.
4. Create deep Industry/Education Alliance that supports student success.

Because of the lockdowns during the pandemic, much of the MNT-EC activities in year 1 took place on-line. 89% of the outreach events of the center were conferences or seminars/workshops. The full range of events are found in Figure 4.

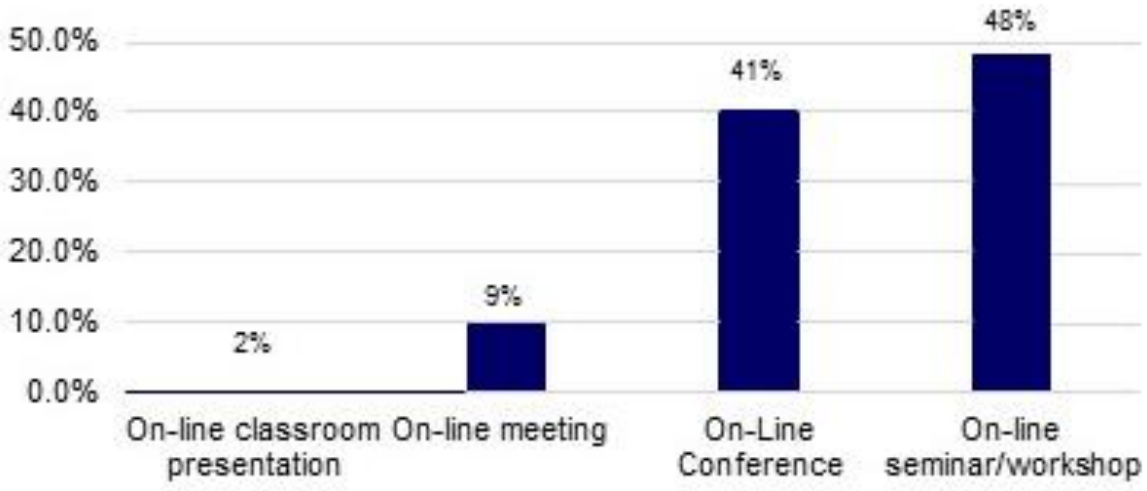

Figure 4: Outreach by type of event

Although there are many stakeholders in micro nano technology education and workforce development, the MNT-EC has identified its intended audience, which is based on the NSF ATE solicitation and the characteristics of micro nano technology companies and career pathways. This audience consists of individuals associated with technological education and representatives of the micro nano technology industry, specifically community college instructors, administrators and students, K-12 teachers, career coaches, university faculty and administrators, and employers who hire micro nano technology technicians.

The MNT-EC reached a total of 3,815 individuals in the first nine months (3,081 in outreach events and 734 through podcasts and YouTube). The on-line platforms did not always have the capability of reporting the characteristics of the audience, and this measure is not as robust as it would have been with face-to-face outreach events. However, the information on audience categories was obtainable for 71% of the events and the distribution of the audience is shown in Figure 5 below:

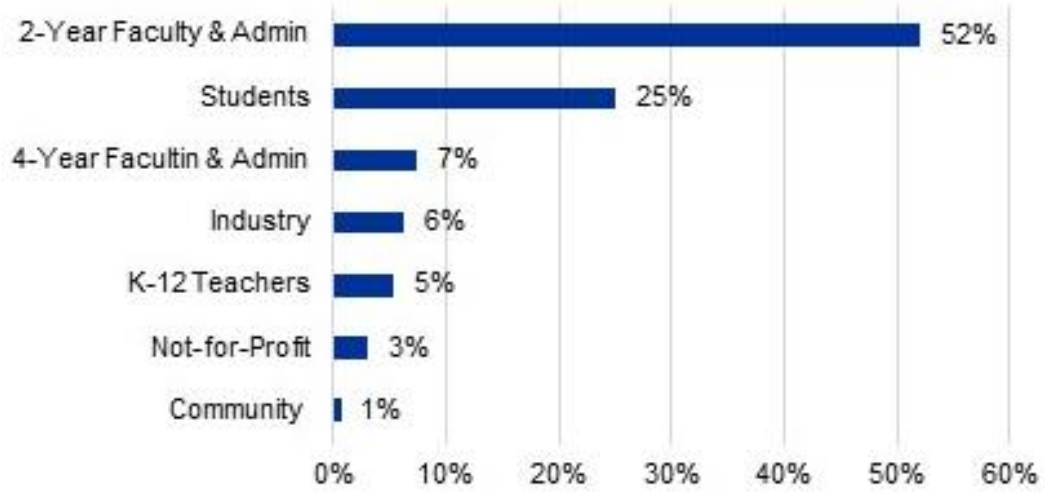

Figure 5: Distribution of Outreach by Audience Category

Data was obtained from attendees of the MNT-EC Seminar Series, seminars that focused on micro nanotechnology technical education programs, diversity, as well as industry relationships, and there were 41 respondents. They rated the quality of the Seminar Series 2020 overall, using a 5-point Likert scale (5 = Excellent, 4 = Good, 3 = Neutral, 2 = Fair, 1 = Poor). With 97.5% of respondents rating the Seminar Series as *Excellent* or *Good*, the series received an overall weighted average quality rating of 4.68 out of a possible 5.00, which is in the range of *Excellent*. When asked about the balance of interactivity and lecture, 90.2% said there was a good balance between lecture and interactivity. Most-often mentioned in open ended questions about the quality of the series were the selection of the topics and resources, high quality presenters, and learning new information.

Participants were asked about the relevance of the seminar series topics to their work. They were offered a five-point Likert scale (*5=Extremely Relevant, 4=Relevant, 3=Somewhat Relevant, 2=A Little Relevant, 1=Not Relevant at All*). Of the 41 respondents, 87.8% indicated that the topics were *Extremely Relevant* or *Relevant*, with only four indicating they were somewhat relevant.

A further pointer to the level of satisfaction with the Seminar Series is that 78% of respondents to the post-series survey indicated that they were interested in additional information about collaborating with the MNT-EC and engaging more fully with MNT technician education. The full range of areas of interest is found in Figure 6 below.

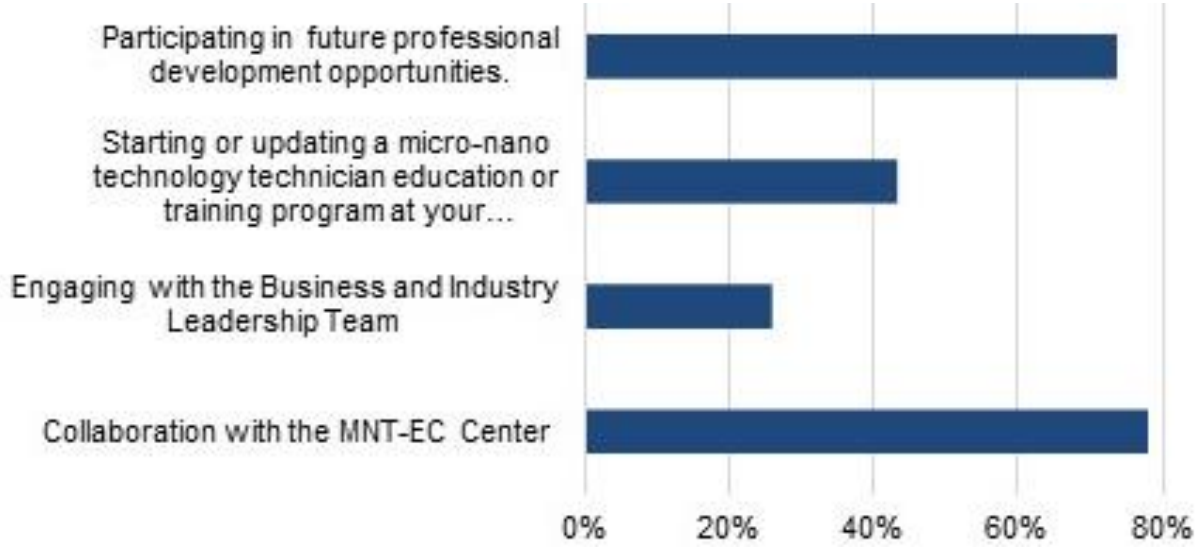

Figure 6: Areas of Interest with the MNT-EC

Comments from the MNT-EC workshops and seminars were positive:

- *"I think this series is important for nano education exposure. I would not know as much about nanotech to share with my research students if it was not for NACK and the MNT-EC"*
- *"Despite the pandemic situation and having all seminars being held remotely, the quality of the seminars were very high. The seminars series was a great platform for initiating new collaborations and activities with micro and Nanotechnology educators."*
- *"I really enjoyed the diversity of topics and speakers for this series. I also appreciated the efforts made to be inclusive with the closed captioning and collaboration with the people at CAST."*
- *"I received so much from the seminars. I found an abundance of information and resources to help build a Nano-biotechnology course for my students."*

In addition to providing engaging workshops and professional development opportunities MNT-EC completed the following major activities::

1. MNT-EC created its website, micronanoeducation.org. Construction began in October 2020 with the website going live on February 12th, 2021. MNT-EC also has an ATE Micro site, nanoHUB group, YouTube channel, and a page on the SCME MNTeSIG website.
2. MNT-EC hosted the 2020 Summer Seminar Series and the 2021 Spring Series. The summer series consisted of 16 1-hour presentations from subject matter experts in the MNT-EC community on topics that ranged from Equity and Diversity and Mentoring with Mentor-Connect to Photonics and Nanobiotechnology. There were 160 registrants for the overall series with each session averaging 55 attendees. This number included return attendees that attended various sessions. The seminar videos were recorded by MNT-EC and edited for publication by nanoHUB staff. In total the videos that are posted have received a collective 444 views. The Spring series consisted of eight webinars/workshops with an average of 12 participants per session.
3. Talking Technicians is MNT-EC's podcast about MNT technicians that shares who they are, what they do and where they come from. Each episode is an interview with a working technician who graduated from a 2-year technician education program. 22 technicians have been interviewed and 17 episodes are posted on the podcast platforms. The MNT-EC website is the top listening platform followed by Google Podcasts and Apple Podcasts. Each episode of the podcast included a technician from an under-represented group in technician education: women, Latinx, 1st generation college, immigrant, single parent, veteran. Each podcast has been converted into an .mp4 video file and can be viewed on MNT-EC's YouTube channel as well.
4. The Journal of Advanced Technological Education (J ATE) launches January 31, 2022 and is a place for Community College faculty to publish peer-reviewed research papers and articles on their work in technician education. The team collaboratively worked on and finalized preparing the journal guidelines including instructions, ethical and publication policies. A major accomplishment was preparing author guidelines, instructions and templates specific to the J ATE. A submission website

has also been created for the received manuscripts. The Journal website page is live and there are currently 4 articles under review.

5. The MNT-EC partnered with 6 community colleges to write a supplemental proposal for undergraduate research; Pasadena City College, Finger Lakes Community College, Edmonds College, Portland Community College, Northwest Vista College, and Southern University of Shreveport, Louisiana, and eight research institutions; University of New Mexico, California State University, Northridge, University of California, Riverside, Louisiana Tech University, University of Indiana, University of Illinois, Purdue University, and Princeton University. The project will provide community college students a year-long research experience using remote technologies and a summer capstone experience. The proposal was submitted under the Dear Colleague Letter: Undergraduate Research in Advanced Technological Education for $1,500,000 and awarded in April 2021.
6. The Mentoring team led the Center's initiative on mentoring activities. Collaborating with Mentor-Connect, the team created a co-mentoring model that allows MNT-EC mentors to work with Mentor-Connect and provide subject matter expertise and proposal development mentoring for MNT grant writers. In year one, the MNT-EC team mentored five different proposals. To date, all five of these proposals have been awarded.
7. MNT-EC is working with the Convergence Technology Center to create a Business, Industry Leadership Team (BILT). The BILT had its first meeting on January 26, 2021 with eleven industry and five faculty members and the MNT-EC BILT organizing team for a total of nineteen participants. The meetings are scheduled quarterly. This year the Industry Working Group focused on BILT creation. There have been 10 Industry Working Group meetings since July 1st, 2020 on BILT recruitment and set-up. Say something about the MEMS KSA's meeting and the trends meeting.

Discussion: Future Directions

The Micro Nano Technology Education Center is currently in year two of a five-year grant cycle. Focus thus far has been on creating a cohesive community of MNT educators, industry leaders, and community members to develop future thinking ideas for community college micro nanotechnology technical education programs. It is the goal of MNT-EC that over the next year impact data is generated to determine the effectiveness of new Center content to help evolve the direction the MNT-EC takes. The MNT-EC plans to disseminate the impact data in the near future to help guide the MNT community college workforce development programs.

Acknowledgements

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