MNT-EC
Micro Nano Technology Education Center

An NSF/ATE National Center

DUE 2000281

EVALUATION REPORT

Year 1: April 2021 to March 2022

Presented to:

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WORKFORCE DEVELOPMENT ◈ WORKPLACE EFFECTIVENESS

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This report would not have been possible without the collaboration of the MNT-EC Principal Investigator, Jared Ashcroft and the Center Manager, Billie Copley. Ms. Copley met weekly with the evaluator to review center activities and evaluation plans and arranged for monthly meetings with the PI to strategize and address any evaluation issues that were arising.

In addition, Ms. Copley worked tirelessly with the Center Team members to prepare detailed reports on the activities and outcomes of their efforts in year two. She curated the data and produced the appropriate level of detail in the information for the purposes of evaluation. Both the PI and the Center Manager were consistently available to discuss evaluation matters.

In addition, all of the Center Team members (20) were helpful and sincere in their desire to support evaluation, and produced the information requested. The team was very responsive to questions from The Allison Group. MNT-EC team members who made presentations and led seminars collaborated on the development of survey instruments that applied to their work with the center.

The PI and the Center Manager were highly supportive of evaluation, and invited The Allison Group to present the evaluation philosophy, design and schedule more than once for both the Center Team and Executive Team meetings. In addition, the evaluator was welcomed at all of the working group meetings. This access to the team members and working groups helped pave the way for relationship-building with the evaluator, and a collaborative effort for the evaluation of the grant.

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List of Acronyms

AACC	American Association of Community Colleges
ACTE	Association for Career and Technical Education
ASEE	American Society for Engineering and Education
ASTM	American Society for Testing and Materials
ATE	Advanced Technological Education
BILT	Business and Industry Leadership Team
CAST	Center for Applied Special Technology
CA2VES	C for Aviation and Automotive Technological Education Using Virtual E-Schools
CCP	Community College of Philadelphia
CCURI	Community College Undergraduate Research Initiative
CNEU	Center for Nanotechnician Education and Utilization at Penn State University
Co-PI	Co-Principal Investigator
CTE	Career and Technical Education
DEI	Diversity, Equity and Inclusion
DUE	Division of Undergraduate Education
FLC	Fingerlakes Community College
HI-TEC	High Impact Technology Exchange Conference
IEEE	Institute of Electrical and Electronics Engineers
INWG	Implementing Nano Working Groups (NACK)
J ATE	Journal of Advanced Technological Education
KSAs	Knowledge, Skills and Abilities
MANCEF	Micro, Nano and Emerging Technologies, Commercialization and Education Foundation
MatEdU	National Resource Center for Materials Technology Education
MNT	Micro nano technology
MNT-EC	Micro Nano Technology Education Center
MNT-CURN	Micro Nano Technology Collaborative Undergraduate Research Network
MNT^{e}SIG	Micro Nano Technology Education Special Interest Group
NACK	Nanotechnology Applications and Career Knowledge [Network]
NCAT	National Center for Autonomous Technology
NCPN	National Career Pathways Network
NETS	Nanotechnology Educators Topical Seminar
NEATEC	Northeast Advanced Technological Education Center
NIIT	National Institute for Innovation and Technology
NISE	National Informal STEM Education [Network]
NNCI	National Nanotechnology Coordinated Infrastructure
NSF	National Science Foundation
NVC	National Visiting Committee
NCyTE	National Cybersecurity Training and Education Center
OER	Open Educational Resources
OSHA	Occupational Safety and Health Administration
PCC	Pasadena City College
PD	Professional development
PI	Principal Investigator
SCME	Support Center for Micro Systems Education
STEM	Science, Technology, Engineering and Math
TAG	The Allison Group
VR/AR	Virtual Reality/Augmented Reality
NCAT	National Center for Autonomous Technology
NCPN	National Career Pathways Network
NETSS	Nanotechnology Educators Topical Seminar Series

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EXECUTIVE SUMMARY

The center is on track to meet its goals and objectives, and had a strong year in terms of outcomes and results produced. All of the five-year metrics are on track to be met, and one has already been exceeded. The MNT-CURN is off to an outstanding start, exceeding many of its metrics and adding a MNTFolio feature which will be useful to the center overall and perhaps to other centers as well. Finally, MNT-EC is a leader in establishing innovative collaborations across centers and disciplines in ATE.

In its second year, the center discovered some challenges to its operations as originally planned in the proposal, which is common for centers. These challenges have affected some isolated results, but overall the center outcomes and outputs remain strong. The challenges discovered this year include overlapping goals and objectives between MNT-EC and other centers, with subawards creating some confusion. In addition, the team grew significantly in year two, and the meeting structure needs to be revised to fit the current size and configuration of the team members and roles. Further, the center management needs to motivate team members to use the Teams file sharing format.

In year two the center reached 4,825 individuals (4,534 of which were faculty and students) through outreach events, professional development, podcasts and YouTube, representing a 26% increase over year one. Overall, the MNT-EC is clearly reaching its intended audience in terms of two-year college faculty and is exceeding expectations in reaching students. While its reach in terms of industry is less than optimal, the BILT mentor Ann Beheler has emphasized that building industry participation takes time, often many years. The BILT Lead has engaged with industry leaders one-on-one this year and is working with the PI to leverage the center to gain access to more companies. Further, the center is pursuing an alternative, dynamic database channel for engaging with industry which may gain access to employers more rapidly.

In terms of reach, the number of student participants is exceptionally robust, with the MNT-CURN exceeding its enrollment goal by 65%. Attendees represented eight colleges in five U.S. states and territories. The MNT-CURN was 76% people of color and 40% African American. The center will be applying the same recruitment strategies, reaching out to existing organizations that serve underrepresented students and inviting them to engage with nanotechnology programs.

These results show that the outreach strategy overall is successful in some areas of the center. However, the center is not getting the results it wants in attendance at workshops, media presence and analytics. Both of these are the responsibility of the Outreach Working Group, which currently functions as if it is operating under a partnership between MNT-EC and MNT^{e}SIG /SCME. It is recommended that the center bring the Outreach Working Group solely under the management of MNT-EC.

User perception of the quality of MNT-EC products and services is very high. In year two, the top-rated products and services were the seminars and the website. The MNT-EC users reported high levels of satisfaction with the center's initiatives, products and services. More than 94% of seminar series survey respondents rated them as excellent or good. During year two, the website was by far the most frequently used MNT-EC resource, followed by career awareness materials and podcasts. Given that this is the first full year for the website, it is notable that its traffic was significant, and equal to or greater than that for other, more mature national centers.

The jump in the downloads of the podcasts was a big success. The podcasts were well-promoted thanks to the efforts of the podcast host's consistent efforts to remind people of the podcasts and for posting the link in the chat of every ATE-related Zoom session he attended. The expansion of the role of MNT-EC's

Media Specialist will focus on posting to social media, bringing a stronger presence to the MNT-EC Bulletin and You Tube videos in the coming year.

The degree of impact on systemic change regarding education of the micro nano technology workforce was indicated through eight MNT-EC initiatives in year two:

- Leveraging the sway of the National Center to influence how community colleges and industry work together to address the current shortage of microchips and projected need for technicians
- A strong emphasis on minority participation in the center's undergraduate research experience
- Podcasts spotlighting micro nano technology technicians who are from minority populations
- Accessibility
- Inauguration of a peer-reviewed Journal of Advanced Technological Education
- Growing the number of ATE proposals in MNT
- Micro nano Technology Community
- Capacity Building

All of these had elements of innovation, and many creative approaches to advanced technological education that were noticed by other projects and centers in the ATE community. They began to consider partnering with MNT-EC and adopting or adapting these innovations, thus already bringing change to the system by the end of year two.

Recommendations include changing the funding model for some center subawardees, bringing all activities and coordination of the working groups under the center's management, and continuing to work with MNTeSIG as an outreach partner.

A major strength of the MNT-EC is the expansive vision for the center held by the PI and Center Manager. They keep that vision front and center with the Executive and Center teams, with high expectations for producing results and outcomes. That in its second year, there are eight major initiatives that are producing systemic change in micro nano technology and STEM education is an extraordinary accomplishment.

Team members are sincere in their support of the center and the center's outcomes and results are strong. The center is well positioned to exceed its goals and objects, and to expand its impact on the MNT workforce and on the ATE community in the years to come.

INTRODUCTION

The Micro Nano Technology Education Center is a national center for the National Science Foundation's (NSF) Advanced Technological Education (ATE) program. This report provides evaluation of the second year of the grant with a reporting period of April 1, 2021 to March 31, 2022.

In July 2020, the National Science Foundation approved a five-year Advanced Technical Education award ($7,483,731) for the Micro Nano Technology Education Center (the MNT-EC), DUE 2000281. In November 2021, a supplemental award ($1,541,586) was granted to fund a program in undergraduate research experience (URE) called the Micro Nano Technology Collaborative Undergraduate Research Network (MNT-CURN). This first year of the MNT-CURN was devoted to a pilot program. The results and outcomes of the MNT-CURN program are integrated into MNT-EC year two evaluation report that follows.

The grant is scheduled to end June 30, 2025. Pasadena City College in Pasadena, California is the MNT-EC fiscal agent.

Center Goal and Objectives

The overarching goal 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. The center has four objectives with associated activities and deliverables.

Objective 1: Develop coordinated national approach to advance MNT education.

Activity 1.1 Strengthen current and foster creation of new programs across US

Activity 1.2 Develop single curated online repository and distance education opportunities

Activity 1.3 Survey industry to identify educational needs in technical education

Deliverable/Outcome: Program Design and National Implementation; Responsive programs designed in accordance with emerging needs and evolving workforce requirements

Objective 2: Deliver professional development to enhance knowledge, skills, and abilities.

Activity 2.1 Facilitate workshops and professional conferences on emerging MNT technologies

Activity 2.2 Deliver hands-on laboratory education

Activity 2.3 Produce industry and education podcasts

Deliverable/Outcome: Professional Development; Faculty will integrate new information about MNT trends into courses and programs.

Objective 3: Conduct strategic outreach, recruitment and retention of traditional and underrepresented faculty/students.

Activity 3.1 Coordinate effort to recruit African American, Latin/x and women faculty and students

Activity 3.2 Provide support and outreach to active duty military and veterans

Activity 3.3 Communicate MNT career benefits to increase awareness among students and parents

Deliverable/Outcome: Targeted Outreach, Recruitment and Retention; Increased faculty/student engagement, persistence, retention and completion, leading to more diverse workforce.

Objective 4: Create deep Industry/Education Alliance that supports student success.

Activity 4.1 Provide work-based learning opportunities to students through industry connections

Activity 4.2 Create internships and employment database

Activity 4.3 Organize a national Business & Industry Leadership Team (BILT)

Activity 4.4 Define and Correlate Student Outcomes with Industry Skill Requirements

Deliverable/Outcome: Workforce Development; Increase the quality of MNT programs and advocates for our graduates, leading to increased workforce placement.

Audience

The target audience for the MNT-EC is made up of ATE PIs and co-PIs, community college, secondary, and university faculty, undergraduate students, employers and industry representatives. A secondary audience includes members of the ATE community such as project staff, grants specialists and secondary and post-secondary education administrators and career coaches.

Logic Model

The MNT-EC's logic model (Figure 1) provides a view of the center's theory of change. This year the MNT-CURN logic model was merged into the center logic model (italic type). It includes the activities, outputs (products and services) and the short-term, medium-term and long-term outcomes (impacts).

Activities	Outputs	Short-Term Outcomes	Mid-Term Outcomes
Convene a national collaborative with focus groups	National MNT Conference	Increase in women and minority faculty participation in MNT education	An industry-driven national collaborative to promote micro nano technician education pathways that diversify and optimize MNT workforce
Recruit new MNT partners	PD opportunities for faculty	Increase in active military veterans in MNT education	Broaden scope of micro nano to programs in electronics, biology, materials, etc.
Facilitate MNT PD faculty workshops & hands-on labs	A central curated and searchable repository of open source AMT educational materials	Active and robust BILT	National focus that deepens and strengthens partnerships between community college faculty and industry
Recruit women and minority faculty to center leadership	New MNT education programs & curricula	Sustainable degree/certificate pathways that continue after the MNT-EC grant ends	Responsive programs designed in accordance with emerging needs and evolving workforce requirements
Establish a website with curated on-line repository	On-line educational materials, distance education courses & virtual labs	Replicable model for outreach to K-12 schools and community organizations	Increased faculty/student engagement, persistence, retention and completion Stronger advocates for MNT graduates
Update current and foster creation of new MNT curriculum & programs	Distance education opportunities	Increased knowledge base on MNT and its implication in emerging STEM fields	Increase in the quality of MNT programs
Establish on-line coursework & virtual labs	Transition Assistance Program for veterans	Active and robust BILT	Increased number of grant proposals submitted to ATE
Provide work-based learning opportunities	MNT mentorship program	Increased awareness of the MNT career and education opportunities	Recognized leadership for micro nano technician education in an environment of disparate stakeholders
Conduct outreach to active duty military and veterans, community orgs and K-12	Podcasts	Increase in students' and educators' positive perception MNT and the educational pathway	Increased collaboration and resource sharing between educators, industry personnel, professional associations and ATE centers and projects
Publish OER MNT textbooks, lab manuals blueprint for labs & articles	Published peer-reviewed articles, MNT Educational Handbook, Blueprint	Increased understanding of the strategies and methods required to successfully recruit diverse students and faculty to MNT programs	Improvements in Distance Education, Student Recruitment/Retention, Industry Connections, College Faculty Professional Development and Community Outreach in MNT education
Provide year-long mentorship	On-line internship and employment database	Increase in active military veterans in MNT education	*Sense of community and inclusive environment*
Create interactive internships and employment database	Work-based learning opportunities & internships	Sustainable degree/certificate pathways that continue after the MNT-EC grant ends	*Increased faculty/student engagement, persistence, retention and completion*
Organize a BILT	A workforce development collaborative consisting of community college, university, non-profits and industry partners	Replicable model for outreach to K-12 schools and community organizations	*Cross-institutional collaboration with geographical, structural, and cultural diversity*
Produce industry and education podcasts	New information and MNT trends integrated into courses and programs	Collaboration with SACNAS and MSIs	*Increased participation and awareness in MNT-based technician education*
Obtain educational needs and forward-looking information on emerging technologies from industry	*Targeted outreach*	*Improved recruitment and retention of STEM students, particularly URM*	*Strengthened involvement of industry with MNT undergraduate research*
Provide professional development in Critical Race Theory	*New community college URE programs*	*New strategies for actively engaging students, strengthening career technical education pathways, and diversifying STEM fields*	
Recruit institutions, faculty and students for the MNT-EC URE program with a focus on underrepresented minorities.	*Summer capstone and URE research experiences*	*Internships and apprenticeship opportunities*	
Provide mentorship, community meeting and research experiences	*MNT remote research experiences*	*MNT certification models*	
Partner with industry	*Year-round academic and research support*		

Long-Term Outcomes and Impacts: Increase in community college faculty participating in micro nano technician education, leading to an increase in the number of students who receive technical education degrees, effectively increasing technician workforce participation

Guidance and support to an increasing number of micro nano technician education efforts emerging across the country

A sustainable process to continuously update MNT education curriculum and produce significant change in micro nano technician education

Increase in equity, diversity, inclusion, and completions in micro- and nano-based technician education

Better prepared MNT skilled technical workforce.

Figure 1: the MNT-EC Logic Model

In the short term, the MNT-EC's activities are intended to increase awareness, knowledge and participation of the target audience in MNT technician education. In the medium term, the intent of the center is that the target audience applies that understanding such that there is evidence of transformative change in classrooms, institutions, and organizations, including establishing and strengthening relationships and collaboration. The long-term vision of the center is a strong network of colleges and industry partners with a robust set of micro nano technology programs and courses that produce well-prepared technicians to meet the needs of the micro nano technology industry and the national economy.

EVALUATION BACKGROUND AND DESIGN

Purpose and Framework of the Evaluation

The purpose of this evaluation, in keeping with NSF requirements, is to provide an outside, independent perspective on the impact of the MNT-EC activities on the technician workforce. For the MNT-EC in year two, evaluation findings were used to guide ongoing decision-making and program improvement efforts, document the center's initial impact and effectiveness, and assess its direct benefits.
The external evaluation was provided by The Allison Group (TAG), led by Terryll Bailey, with responsibility for process and outcome evaluation, ongoing consultation and formative evaluation, data analysis and evaluation report development. The external evaluator and Center Manager Copley set a goal to maintain the focus of the evaluation report on outcomes and impacts and the focus of the annual report on activities and results to minimize redundancy in reporting. This year, the evaluative indicators and data sources for the MNT-CURN supplemental were integrated into the evaluation for the center overall.

Welcome Dr. Jalil Bishop

In the third quarter of year two, an evaluator with expertise in diversity, equity and inclusion (DEI) joined the MNT-EC team to work with the external evaluator and the center team. In his first half-year with the center, his focus was on research and evaluation of DEI in the MNT-CURN program. Dr. Jalil Bishop, Ph.D. and CEO of MUME Collective has an impressive track record, including an appointment in the Higher Education division as a Vice Provost Postdoctoral Scholar and Lecturer for the University of Pennsylvania.

Dr. Bishop brings expertise in developmental evaluation and deep experience in program evaluation. In year three, the two evaluators plan to begin to integrate their evaluation philosophies, and to bring a stronger focus on DEI to the full center evaluation.

> Dr. Jalil Mustaffa Bishop's research agenda focuses on how Black people build lives against and beyond racism--what he refers to as Black lifemaking. He studies the role of racism and anti-racism in institutional systems across housing, education, and labor markets. His latest scholarship examines higher education and its connection to societal inequities. He employs community-engaged, qualitative, historical, and policy-oriented research methods coupled with critical theory to question the extent to which education pathways are or can be a social equalizer, particularly for Black students and communities.
>
> He has secured nearly $3 million in grants to support his research and advocacy and reallocate resources to community groups. In addition to his research, Dr. Bishop intentionally remains connected to the student groups and communities he studies. He has served in multiple education programs and centers focused on increasing the success of students of color in higher education and transition to careers post-graduation. His background in anti-racism praxes, Black freedom projects, and coalition building has allowed him to work with activist groups, policy think tanks, presidential campaigns, K-12 schools, community colleges, and community-based organizations.
>
> https://www.jalilmustaffabishop.com/

Figure 2: Dr Bishop Bio

Framework

The framework for the MNT-EC's evaluation is primarily based on adaptation of the Context-Input-Process-Product evaluation model developed by the Evaluation Center at Western Michigan University, under the direction of Arlen Gullickson, Ph.D. and Daniel Stufflebeam Ph.D.[1] The year's activities were evaluated following Stufflebeam's four essential elements:

1. The degree to which the project is achieving its goals.
2. The level of impact, and the degree to which the project is reaching intended individuals or groups.
3. The effectiveness of the products and services delivered to constituents.
4. Ways in which the project can be significantly improved.

The investigative approaches recommended by the Evaluation Project at Western Michigan University were utilized to produce a theoretically based, complete and comprehensive review of the project:

- Objective Orientation: How closely the products and services meet the stated goals and objectives as stated in the grant proposal.
- Teaching/Learning Process Orientation: Based on the perspective of teachers, how the project activities are assisting or facilitating teaching and learning.
- Customer Orientation: From the perspective of students, how the project activities are improving learning, comprehension and retention.
- Faculty and Institutional Support: The degree to which the project efforts are integrated and accepted, and the positive changes resulting from the efforts.
- Business and Industry Support: The level of acceptance and support for the project efforts by business and industry, especially those which hire graduates and utilize the technician workforce.
- Management: The degree to which processes are in place or under development that leverage the effort with the goal of building on the project activities, products and services after the funding period comes to an end.

Each item in the evaluation plan was considered from one or more of the approaches listed above. Project data-gathering activities and subsequent data analysis were guided by standards developed by the Joint Committee on Educational Standards and Evaluation. All active and passive data gathering activities involving human subjects were approved by the appropriate institutions' IRBs (Institutional Review Board).

Evaluation Design

The evaluation design was developed by the external evaluator and includes the evaluation questions, which align with the framework. A report is developed at the end of each year that addresses each of the five evaluation questions:

1. To what degree was the center implemented as planned? What successes were achieved and what challenges were addressed?
2. To what extent did the MNT-EC reach its intended audience?
3. What are users' perceptions of quality and relevance of the center's processes and products?
4. To what degree are the MNT-EC's materials and resources being used?
5. To what extent did the center's work lead to systemic change regarding the education of the micro nano technology workforce?

[1] [1]Stufflebeam, D. L. (2003). The CIPP model for evaluation. In D. L. Stufflebeam, & T. Kellaghan, (Eds.), *The International Handbook of Educational Evaluation* (Chapter 2). Boston: Kluwer Academic Publishers.

In developing the evaluation plan, multiple indicators were identified for each of the evaluation questions. The indicators were developed collaboratively by The Allison Group, the PI and the Center Director. The measures for the indicators include both qualitative and quantitative data. Sources of the data were identified for each indicator, along with the data collection methods and are shown in Table 1 below. This year, the indicators and sources of data for the MNT-CURN were added and are shown in italic font.

Indicators	Data Sources / Timing
Evaluation Question 1: To what degree was the center implemented as planned? What successes were achieved and what challenges were addressed?	
Degree of match between plan and execution of center activities and deliverables, including URE	Review of center documentation, actual vs. plan Includes timeline, implementation plan, center management and activities. (Monthly).
Evaluation Question 2: To what extent did the MNT-EC reach its intended audience?	
Repository users; number and characteristics of attendees at events and professional development; Growth or decline of segments of audience	Counts and registration data of professional development participants; annual center impact survey; review of center documentation and website analytics. (End of each year)
Industry involvement	BILT and other meeting attendance records (End of each year)
Underrepresented minority, veteran and female participation	Center documentation of the Leadership Team and NVC; meeting and MNT-CURN session attendance records; documentation of recruiting initiatives and results. (End of each year)
Annual use of products & services; Growth or decline of segments of audience	Surveys of center stakeholders (End of each year)
# of students recruited each year to MNT-CURN	*Center documentation (Annually)*
# of institutions that add URE and/or MNT programs	*Center documentation (Annually)*
Evaluation Question 3: What are users' perceptions of quality and utility of the center's processes and products?	
Feedback on: National Conference; collaboration processes; career pathways; curriculum development; mentor program; and other center products and services	Annual Center Survey; Event surveys; observation; Respondent's ratings of satisfaction levels regarding quality and utility of aspects of the center/events/initiatives; Respondents' ratings on the benefits and areas of improvement; Respondents ratings of the center/events/initiatives overall. (End of each year; pre/post event)
Indicators	**Data Sources / Timing**
Web-based repository activity including page views and downloads	Website analytics (End of each year)
Feedback from professional development participants regarding PD webinars, workshops & labs	Pre, post and delayed post surveys of faculty participants (At the beginning and end of workshop and six-months to one-year later)
Feedback from working groups and initiatives: Distance Education / Curric. Development Industry/BILT / Mentoring Professional Development / Journal Outreach / Podcasts Veterans / MNT-CURN	Surveys of working group participants on the quality and utility of the working group meetings; working group minutes; informal interviews with working group facilitators; observation and monitoring of correspondence, Evaluation Preparation Questionnaires (End-of-year starting in year 3))
Feedback on the quality and utility of: the remote experiments, distance learning, mentorship, weekly and/or semi-monthly meetings, administration; and research-related and other activities from MNT-CURN students and faculty.	*Surveys, interviews and/or focus groups of faculty and students; observation of events and processes (Ongoing and end of each year)*
Feedback from partners such as CAST regarding the quality of collaboration with the Center	*Surveys or interviews with partners*
Evaluation Question 4: To what extent are the MNT-EC's materials and resources being used??	
Annual use of products & services.	Surveys of center stakeholders; User data from NanoHub; MNT^{e}SIG website data. (End of each year)
Growth or decline of segments of audience	Surveys of center stakeholders asking about frequency of use of center materials, products and services. (End of each year)

Evaluation Question 5: To what extent did the center's work lead to systemic change regarding the education of the micro nano technology workforce?	
Degree of collaboration among stakeholder groups	Review of center documents including meeting/working groups minutes; Survey of stakeholders; strength of relationships (Years 2, 3, 4, 5)
Knowledge, Understanding and Learning	Self-assessments of how much center users learned and whether and to what degree their knowledge and understanding changed
Institutional capacity to educate micro nano technicians, including: new programs added; infusion of MNT concepts into programs in electronics, biology, materials, etc.; addition of distance and work-based learning	Pre-post surveys, working groups and/or interviews with faculty and administrators on impact of center initiatives and educational materials on institutions' capacity to educate micro nano technicians. (End of years 3, 4, 5)
Application of learning	Respondents' intent to apply their learning in the classroom, institutions, ATE Community and the workforce education system; Follow-up surveys to obtain respondents' ratings of their application of their learning and the impact of that application
Level of growth in student recruitment, retention and completion	Longitudinal data from samples of institutions that are engaged with the center (End of years 3, 4, 5)
Increased knowledge and understanding of faculty regarding mentoring of underrepresented students in UR	*Pre-and-post surveys, selected interviews, and/or focus groups with faculty participants. (Beginning and end of each year)*
Reflections of faculty on how participation in the MNT-EC UR program influenced their teaching, their view of student capacities, and their self-efficacy in mentoring, and in teaching URM students in undergraduate research	*Pre-and-post surveys, selected interviews, and/or focus groups with faculty participants on changes in attitudes, beliefs and self-efficacy of faculty mentors about teaching UR and working with URM. (Beginning and end of each year)*
Improvement in student and faculty ratings on 11 pre-determined undergraduate research student outcomes, academic strengths and weaknesses, and self-efficacy and confidence	*Surveys of faculty and students using a common rubric.* (Pre-research; mid-research, and end-of-research)* **Using the automated system provided by Evaluate-UR*
Impact of the UR program on student micro nano technology education and career plans	*Pre-and-post-surveys of students and/or selected interviews or focus groups (Beginning and end of each year)*
Degree of institutional change such as sustainability for UR programs, and/or spread of UR to other departments or institutions	*Surveys of faculty and/or interviews or focus groups. (End of each year)*

Table 1: High Level Evaluation Plan

Data Collection

The data collection for year two of the MNT-EC included development of a center survey and pre-surveys for MNT-CURN students and mentors, online event survey design and distribution, center documentation and development and completion of compilation questionnaires and worksheets. All of the surveys were developed by the external evaluator in collaboration with the one or more subject matter experts from the Center Team and with review and approval by the Center Manager or PI. Once finalized, they were uploaded to The Allison Group Survey Monkey Platform. They were administered by the center staff. A description of the design and response rate for each data collection instrument survey is found below.

Data Sources: Annual Center Survey

The annual center survey was sent to 498 individuals on the MNT-EC mailing list, gathered from attendees and web-site sign-ups. There were 62 completed surveys returned producing at response rate of 12.5%. This is high for the first such survey, with many centers experiencing response rates in the single digits. The survey asked about frequency of use and quality of center products and services, and how center resources are used in classrooms, institutions and companies along with any impacts of their use that were observed. Lastly, the survey asked for demographic information about the respondents.

Data Sources: Online Event Feedback Surveys

Spring and Summer Seminar Series 2021 Survey

The Seminar Series 2020 Survey was offered at the end of each the seminars. Some seminars posted the link in the chat, and followed up with sending a link in an email. Of the 260 attendees of the series, 112 completed the surveys, creating a very good response rate of 43.7%. This survey had twelve (12)

questions that asked about the quality of the seminars as a whole; how much the participants learned; whether they intended to use what they learned and if so, how they intended to use it. The survey also asked about areas of strength and suggestions for improvement as well as demographic information.

MNT^{e}SIG Post-Conference Survey
Twenty seven of the 59 attendees completed the post-event survey, creating an excellent response rate of 45.8%. The 18-item survey asked about the quality of the event and attendees' overall satisfaction with it, as well as what they gained by participating. The survey also gathered information on areas of interest of the attendees in participating with MNT^{e}SIG in the coming year and preferences for the next year's MNT^{e}SIG Conference.

Data Sources: Center Initiative Evaluation Surveys
Proposal Mentoring
The MNT-EC collected feedback on its proposal mentoring initiative in year one. Recipients of the mentoring were asked about the quality and utility of the mentoring, their satisfaction with the mentoring they received and the helpfulness of the mentoring. The survey was distributed to eight mentees and all of them completed the survey, producing a response rate of 100%.

Community of Practice
CoP members were asked about the types of micro nano technology programs and courses they have at their colleges and the number of students currently served, the demographics of students, and percentage of students finding jobs. It also asked about ongoing support the CoP members would like to receive from MNT-EC.

MNT-CURN Survey
In this pilot year, student pre-and-post surveys were developed for the MNT-CURN. A the pre-survey was administered at the start of the program. Consisting of 13 items, it covered perspectives on STEM education and careers; confidence regarding STEM education and careers; career goals; factors that influenced participation in the MNT-CURN; and race, gender and ethnicity. Dr. Bishop added three DEI questions to the survey that covered identity, background, culture and inclusivity; relationship building in education programs; and family income. Of the 31 participants, 28 completed the survey, producing an excellent response rate of 90.3%. Because the post survey will be administered in June, the outcomes and results gleaned from the pre-post survey analysis will not be reported until year three.

Data Sources: Center Documentation
The center completed two compilation forms provided by The Allison Group:

- Evaluation Preparation Questionnaire: The questionnaire contained sections to be filled out that included major achievements and challenges, national/regional leadership, sustainability, impact on students/faculty/institutions and the workforce education system, unanticipated outcomes and synergistic opportunities, and future plans. The questionnaire was completed by the PI and Center Manager, and by the leads for each of the center working groups and initiatives.
- Outreach and Dissemination Worksheet: The worksheet was a shared Excel spreadsheet in Microsoft Teams into which all members of the Center Team entered their presentations and the events and workshops they led, along with information about the sponsoring organization and number and characteristics of attendees. This year, with many of the presentations being virtual, and managed by third-party tech companies, some of the disaggregation of data by category of audience (e.g. 2-year faculty, employers and industry, etc.) was not available. MNT-CURN student session attendance and publications were also reported on this worksheet.

The center also submitted meeting notes and minutes and recordings of Zoom meetings and sessions. In addition, the external evaluator attended meetings of all of the working groups, Executive Team meetings, Leadership Team meetings, and many of the webinar offerings, and had notes from observations.

Importantly, the external evaluator met weekly with the Center Manager and monthly with the PI and Manager to stay current on the center activities and to coordinate the implementation of the evaluation plan.

Data Analysis

The data collected by the center was both quantitative and qualitative in nature. The quantitative data were analyzed using descriptive statistics. In particular, top-two box scores, means and weighted averages were calculated and data were primarily presented in tables and as percentage frequencies

Two methods for calculating means/averages were employed in the data analysis:

1. When the term mean is used in the report, it was calculated by adding the numbers in the array and dividing the sum by the count.
2. When the term weighted average is used in the report it refers to the average value of a set of numbers with different weights. This situation occurs when a rating scale is used with relative values (weights) attached to the quantitative or qualitative attributes in the scale (i.e., agree/disagree, excellence, likely/not likely, etc.). The weighted average is calculated using the formula below, where x = the # of responses for the attribute and w = the value assigned to the attribute.

$$\frac{\sum (x_1 w_1 + x_2 w_2 + x_3 w_3 + x_n w_n)}{\text{Count}}$$

Below is an example of a rating scale with weights assigned and # of responses for each item on the scale:

Attribute	Value/Weight *(w)*	# responses *(x)*	*(x)(w)*	Weighted Average
Excellent	4	6	24	
Good	3	10	30	Sum/Count
Fair	2	4	8	64/22
Poor	1	2	2	
		Count = 22	Sum = 64	2.90

Table 2: Example of Means/Average Calculation

The qualitative data were gathered via open-ended questions. Standard qualitative analysis methods were used to examine and analyze the data collected from open-ended questions in the surveys. The goal was to identify themes in the responses. The strategy used to identify themes used multiple techniques in a sequential manner:

1. Responses were reviewed to identify key words and concepts.
2. Key words were grouped.
3. Comparisons were made across respondents.
4. Word repetitions/key words and concepts were analyzed.

Limitations

One limitation regarding the ability to draw conclusions with respect to the MNT-EC is the sample size. All of the survey populations were small, and even with response rates of 32% to 95%, the sample sizes in year two were too small to be conclusive. However, this data can act as pointers to areas of success, and areas for improvement.

Second, it is well-known that self-reported data have a number of limitations. Self-reported data can rarely be independently verified, and what people say has to be simply taken at face value. In addition, self-reported data is susceptible to biases that come from memory and recall functions of the human brain and errors in attribution.

A third potential limitation is sampling error, which results when members of the population who respond to the survey request self-select to participate or not to participate, which can lead to biased response data. The characteristics of those who agree to participate in the survey have been found to be different from the characteristics of those who do not respond to the survey. For example, those who opt-in may have more positive experiences and perceptions than those who do not take the survey. This can lead to under-coverage of some members of the population in the sample, and biased results.

EVALUATION QUESTION 1: To what degree was the center implemented as planned? What successes were achieved and what challenges were addressed?

The center and the undergraduate research experience (MNT-CURN) were implemented according to the plans articulated in the proposals. The MNT-CURN is exceeding its planned results and the center is meeting or exceeding many of its goals, but is behind schedule on some of the benchmark metrics (see Table 3) due to some challenges that became apparent this year. However, the PI and Center Manager are aware of the challenges and are prepared to address them. The center is positioned to meet or exceed all goals and objectives.

A synopsis of the center's administration and implementation in year two is below, including metrics, the new product - MNTFolio, the new initiative - MNT-CURN, the website updates, collaboration strategies and the NVC meeting. The results of the core initiatives of the center in year two are found in subsequent sections of this report.

Center Deliverables and Metrics

The grant proposal listed eleven deliverables with metrics for the center to complete. They are listed in Table 3 along with the status toward completion. The center planned for some deliverables to start in years two and three, and some were delayed primarily due to the COVID-19 pandemic. The center has already met the target for professional development and conference outreach to faculty and the target for minority representation on the Leadership Team. It is positioned to meet the remaining targets if activities are implemented in year three as planned.

Deliverable and Metric Status	Target End of Y5	Cumulative to Date	Y1	Y2	Y3	Y4	Y5
MNT programs or ATE grant in MNT (# colleges)	**25***	10	9	1			
Industry partners	**100**	32	11	21			
Faculty in hands-on PD	**500**	37	Y2	37			
% URM in leadership	**50%**	55%	42%	55.3%			
Veteran Tech	**125**	0	Y2	0			
Community colleges trained in educating veterans per year	**15**	0	Y2	0			
Single on-line source of industry opportunities for students	**1**	0	Y4	Y4			
# of faculty that attend conferences and professional development	**1,250**	1,995	75	1,920			
Talking Technicians Podcasts	**90**	28	12	16			
MNT in the Community Podcasts	**90**	0	Y3	Y3			
Employer-sponsored work-based learning internships	**25**	0	Y3	Y3			
* Lowered from 50 to 25 at the start of year two							

Table 3: Center Deliverables and Metrics

Standing Up the Center

The center structure, as described in the proposal was established in year one, and it expanded in year two. The structure consists of the Executive Team, Working Groups, and the Initiatives. (See Figure 3).

The MNT-EC is organized by working groups and initiatives representing distinct center objectives and/or operational components. Each has identified leads, functions and deliverables. The leads are members of the Center Team and are paid for their work. The working group participants are volunteers from the micro nano technology community. The working groups have between one and ten volunteers that regularly attend working group meetings.

In all, there are 45 individuals filling 43 roles for the center. The complete center administration is found in Appendix 1.

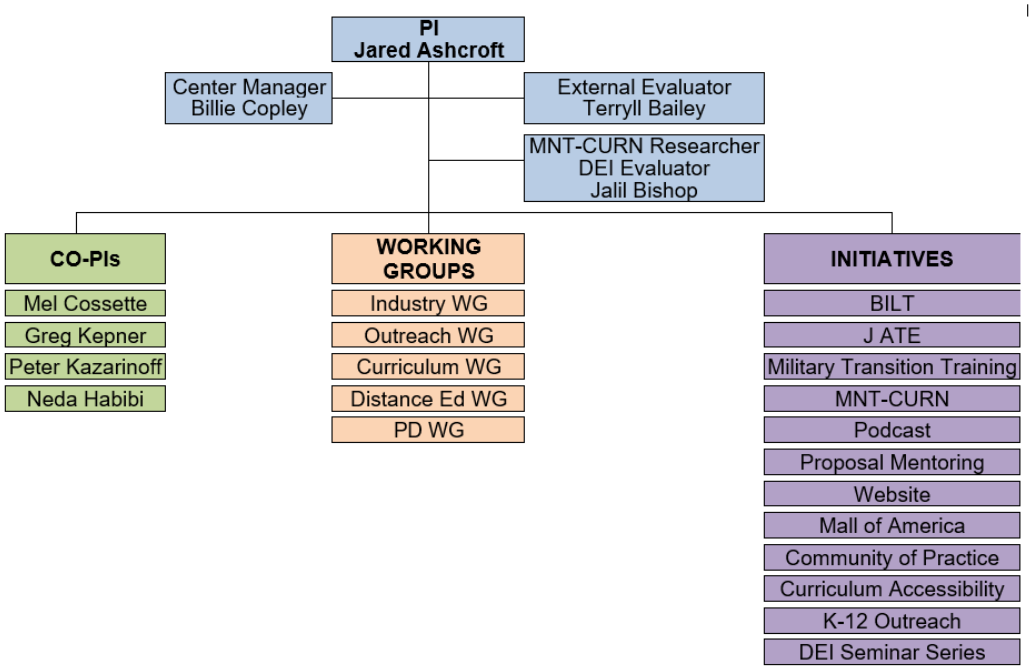

Figure 3: MNT-EC Center Organizational Structure

Center Team and Management

The MNT-EC Center Team meets monthly and includes the PI and Co-PIs as well as working group leads and experts from partner institutions, and experts under contract. The Executive Team consists of the PI, Center Manager and Co-PI's and meets weekly. Community and partner collaborators provide insight into best practices in their areas of expertise. Center working groups establish their annual goals aligned with the center goal, and develop plans to accomplish them, with feedback from the PI and Center Manager.

The center has made significant progress toward its goals this year, and also has discovered gaps in productivity and how the center is going about producing its products and services. The analysis of the data and the reporting are providing the data-driven approach to define the gaps, to identify the most effective ways to address them, and make the center even more productive in year three.

As the standing up of the center was completed in year one and became operational in year two, the challenges of managing its complex organization became more apparent. With co-PIs and other major leaders involved in multiple working groups and initiatives, the number of meetings they needed to attend grew, along with the number of tasks they needed to complete. A few challenges emerged in year two.

- Many of the members of the Leadership Team have current or prior experience as ATE PI's or Center Managers and content knowledge of micro nano technology. While this means that they bring deep expertise to the center, as year two unfolded it became apparent that they also bring competing goals and agendas with them. It is understandable that the current and former PIs of ATE centers with years of effort going into their projects and centers, might have a difficult time transferring those efforts to MNT-EC. For example, past centers (that have sunsetted) sharing of mailing lists and industry contacts has not occurred in a timely fashion. Also, the Professional Development Working Group focused on past center-specific professional development, with little workshop planning or production for MNT-EC this year. All of the professional development for year two was led by the PI and Center Manager and took place in 2021. In a third example, some working groups' agendas covered the items of interest to the chair's organization rather than focusing on MNT-EC's activities.
- With all of the moving parts of the center, not all of the Leadership Team members are clear about their role and how the parts work together. This was evidenced in year-end reporting by working group leaders regarding work and results that were also claimed by other ATE grants. MNT-EC did not claim these activities nor their outcomes, which led some of the sub awardees to have fewer results than expected, or even no results for this year. With many members of the Leadership Team under subaward or contract, the question arises as to the return on that investment for MNT-EC, as some of the MNT-EC efforts are producing outcomes for other organizations rather than the center. It is recommended that the PI and Center Manager review the roles and pay structure for each team member and make revisions as needed.
- There is not agreement by the team to use the Microsoft Teams site. Team members see it as option and some have opted for Google Docs for their working groups. This leaves the Center Manager without access to information about the center's activities. It is recommended that the PI/Center Manager, or a hired professional facilitator, conduct an open discussion with the team members and bring the group to consensus as to the file sharing application that everyone will use. The center is in an insecure position if the senior leadership cannot access the documentation regarding its activities, plans and results.

Originally it was planned that the monthly Leadership Team meetings would be an opportunity for the various working groups and initiatives to coordinate their activities and engage in continuous improvement and problem solving. However, the expansion of the Leadership Team in year two has

meant that its meetings have become an avenue for the PI and Center Manager to provide updates on center initiatives, and to occasionally spotlight one of the working groups. It is important to continue have these informational meetings and to disseminate center information to the leaders in this way.

With the Leadership Team meetings taking this turn, it has become vital that there are regular meetings for the Working Group and Initiative Leads so they can share what's working and not working, ideas for the center, progress toward goals and objectives and for working together. The Working Group and Initiative Leads comprise the operational core for the center, and their input and coordination can provide a channel for process and impact improvement.

Website Design and Development

The MNT-EC hired Mackey Creative Lab to create its website, https://micronanoeducation.org/, and this organization has done a good job improving the website and providing expertise and consultation for the center. The focus in year two was building out the content for the website. This occurred in two major areas: MNT-CURN and J ATE.

MNT-CURN

The MNT-CURN page was primarily a place-holder at the end of last year. This year, the center performed a major overhaul that included updating the description, the applications section and the look of the page. It also included the addition of student, student mentor and faculty mentor pictures and bios for most (some did not want to be added or listed).

Journal of Advanced Technological Education

The primary change regarding the webpage for the journal this year was to change the name to Journal of Advanced Technological Education, reflecting the major shift of the publication from micro nano technology to all of ATE. This included the name and logo for the journal, and updating the editorial board members. In addition, the first issue was e-published this year, and the webpage was the host for that first issue.

National Visiting Committee

One member of the NVC resigned, and two new members joined, bringing the total number on the NVC to 13. In terms of affiliation, industry and two-year institutions (including the two national center PIs) have the greatest representation as shown in Figure 4 below:

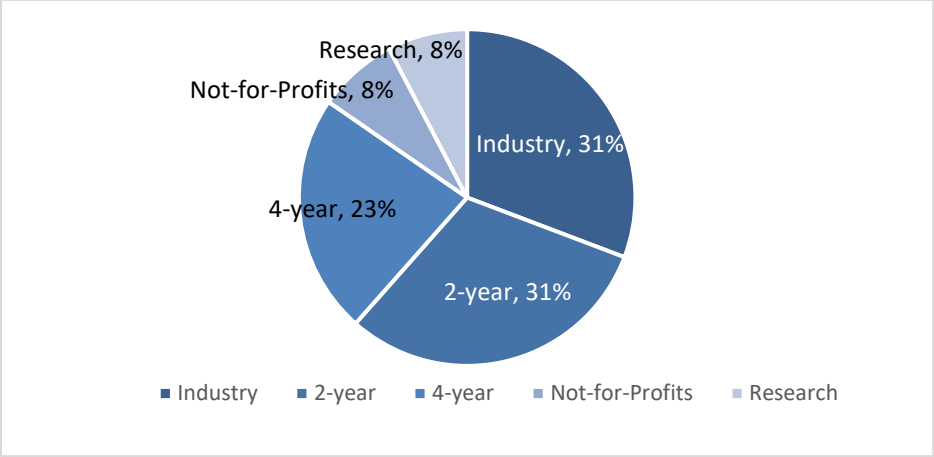

Figure 4: NVC Members

The NVC is a distinguished group, many of whom have extensive experience serving on NVCs and other professional boards. The complete list of the NVC members is found in Appendix 2. The center conducted an NVC meeting on June 9-10, 2021 to reflect on its first year of operation. The committee met with the leadership team of the Micro Nano Technology Education Center, through a virtual meeting that spanned two days. Day one covered a presentation of the center's activities by the team and day two included an overview of the MNT-EC website, work time for the NVC and a brief report out. Eleven of twelve NVC members were able to attend and they acknowledged the professionalism and organization of the event. The NVC reported on the strengths and opportunities they saw for the center, based on the information presented.

MNTFolio

MNT-EC formed a partnership with CAST, a nonprofit education research and development organization. CAST developed the *Universal Design for Learning* framework and *UDL Guidelines* to increase the inclusivity of learning materials and processes. In year two CAST designed a version of its e-portfolio tool, customized especially for this project and named the MNTFolio.

Using key competencies and skills required by industry and based on prior research, CAST worked with micro nano technology educators to develop challenges (mini-assignments to facilitate development of individual portfolios) and led professional development workshops to support MNTFolio's implementation. Educators can evaluate student responses using a built-in rubric and provide feedback to students, who can then use that feedback to retake a challenge and improve their portfolio. At the culmination of students' research projects, they will use the materials created to develop an accessible e-portfolio that showcases their work. They can digitally share their folio with a prospective employer or university admissions officer.

The MNTFolio was piloted with the MNT-CURN students and there are currently six challenges in varying degrees of completion. Users will provide feedback on the usability of the MNTFolio and its effectiveness in documenting and supporting student skill development which will be reported in year three. However, preliminary feedback is that students and mentors are finding they do not have the training needed to create accessible content. CAST is developing a how-to video to address this. In addition, the center is finding that the current inventory of challenges is not sufficient to keep the students engaged.

MNT-CURN

The supplemental award to the MNT-EC grant funded its MNT-CURN program, the purpose of which is to provide undergraduate research experiences to students, and particularly students from underrepresented groups over a four year period, ending in June 2025. The first year was dedicated to piloting the MNT-CURN program. It started in the fall of 2021 and will complete at the end of the summer term of 2022.

In the fall through the spring terms, students engaged in programmatic activities to increase their content proficiency, engage with their mentors, developed their research plan, and community building. In the summer capstone research experience, students will engage in two-to-three-week research internships at major university sites, implementing their research plan. Students, in consultation with their mentors and project leadership, have selected a research site that fits their project. Placement and documentations required for students to participate at the universities were handled by the MNT-EC center and travel and lodging are paid for by the NSF supplemental funding.

Evaluate-UR
Evaluate-UR is a process that uses evidence-based data to measure the outcomes of undergraduate research experiences. Originally funded by the National Science Foundation (DUE 1347681) and developed at SUNY-Buffalo State, Evaluate-UR is used by students to learn about their academic strengths, areas for improvement and the academic and employability skills needed to be successful in a technical workplace. This takes place in an inclusive learning environment in which students rate themselves on eleven outcome categories, compare their ratings to those of their mentors on those same eleven outcomes, and have an open dialog with their mentors about their self-perceptions vs. those of the mentors. Students and mentors have a dashboard showing their progress (e.g., completed steps and steps remaining to be completed). For each student-mentor pair a built-in statistics package generates summary measures for each outcome. Through the regular feedback, assessments and conversations with mentors, following are the typical outcomes for students:

- A realistic picture of their strengths and weaknesses across the eleven outcome categories.
- Development and/or enhancement of their metacognitive skills.
- Greater self-awareness and confidence.
- Stronger applications to baccalaureate programs and/or resumes for entering the workplace.

The MNT-CURN is gathering feedback from students, mentors and administrators that will be applied to a continuous improvement process for year two.

First Cohort, Mentors and University Partners
The first cohort of students was formed with 31 total, dramatically exceeding the goal of 20 for the pilot. The cohort of students was from eight community colleges in five states. The cohort had nine faculty mentors. In addition, three student mentors who are former community college students now enrolled at universities hold office hours each week to assist students in their coursework and research. There are a total of 14 university partners and they are hosting summer capstone research experiences on their campuses or remotely. https://micronanoeducation.org/students-parents/micro nano-technology-collaborative-undergraduate-research-network/

Next year, the project will recruit 50 students to the MNT-CURN program, and the evaluators will work together to evolve the assessment practices to get a better understanding of effectiveness of program.

Funding
Students were provided stipends through the MNT-EC supplemental funds for their participation in the weekly sessions and the summer capstone experience. In addition, several undergraduate research partners are providing additional stipends for the summer undergraduate research experience for MNT-CURN students (USC, Caltech, University of New Mexico).

Further, a biproduct of the MNT-CURN program was that PCC and Caltech jointly applied for and received START funding to provide students longer internships. The START funding provided three PCC students year-long internships at Caltech.

Students from Underrepresented Groups
All of the students were from community colleges, and over 90% of the cohort was comprised of underrepresented groups, with 75% of the cohort identifying as BIPOC and 34% identifying as female or nonbinary. Recruitment was greatly advanced by the partnership with Community College of Philadelphia Center for Male Engagement, which increased the participation of African Americans in the program. Of the 31 students in the program, 13 are African American, including students from the START program. The work of Dr. Kendrick Davis and Dr. Jalil Bishop played a major role in the success in recruiting African American students to the MNT-CURN

Student Engagement
Weekly meetings were conducted for students with guest speakers who covered scientific concepts, career opportunities, and what it is like to be a professional in a STEM career. There were over 30 presentations by research university faculty, industry leaders, and ATE Centers. Presentations included such topics as technical education programs, apprenticeship/internship programs and research universities presenting on research topics such as quantum education, nano-biomimicry and MEMS Manufacturing. Students were offered the opportunity to use the MNTFolio and provide feedback.

The students were provided access to research and internship opportunities in the micro and nano sciences in residence at four-year universities. Through these summer capstone experiences, students will have the opportunity gain access to advanced research and technology; increase their knowledge and abilities in cutting-edge research; gain access to university research mentors to increase their critical thinking, innovation, communication, and leadership skills, leading to increased success in STEM.

Collaboration and Partnering

The MNT-EC is strongly oriented to collaboration. In its second year it continued the successful collaborations that started in year one, through a variety of activities. Monthly meetings with PIs from other national centers, initiated by MNT-EC in its first year. PIs of the National Center of Autonomous Technologies-(NCAT) and InnovATEBIO, and the group expanded in year two, to include the National Cybersecurity Training and Education Center (NCyTE), and National Center for Next Generation Manufacturing (NCNGM). MNT-EC worked on supporting NCAT's Experience STEAM ATE Showcase, invited Centers to collaborate on the Journal of Advanced Technological Education, invited Centers to participate in the Talking Technicians podcast, led discussions on how to leverage multiple Centers in organizing professional development programs and on how to collaborate to meet the imminent needs of the semiconductor industry.

Additionally, the center wrote twenty commitment letters in support of NSF grants, all of which contained specific commitments of support on the part of MNT-EC. Further, MNT-EC is supporting NACK's Integrating Nano Working Groups (INWG) by providing micro nano technology instructors to lead the community college group in following up on the NACK professional development to develop and use MNT modules in the classroom, funding the lead for the NACK INWG K-12 Outreach Group, and funding 50% of Zach Gray and Bob Ehrmann in their positions with NACK.

The center also collaborated with multiple ATE centers and projects to address systemic challenges in advanced technological education such as special needs students, certification models for MNT community college programs and industry, NCAT's Experience STEAM event at the Mall of America, undergraduate research and quantum education.

Oak Crest Institute resigned from the center in year two. The center is still defining the various categories of partner that it has or plans to have. The full list of MNT-EC partners as reported by the center is found in Appendix 3 (not including the partners with subawards listed in Appendix 1).

Conclusions

The center is on track to meet its goals and objectives, despite discovering some challenges in the structure originally planned in the proposal. These challenges have affected some isolated results, but overall, the center outcomes and outputs remain strong. All of the five-year metrics are on track to be met, and two have already been exceeded. The website is on a continuous improvement cycle which keeps it fresh and up-to-date. The MNT-CURN is off to an outstanding start, exceeding many of its metrics and adding a MNTFolio feature which will be useful to the center overall and perhaps to other centers as well.

Finally, MNT-EC is a leader in innovation and in establishing and maintaining collaborations across centers and disciplines in ATE.

The challenges discovered this year include overlapping goals and objectives between MNT-EC and other centers, with subawards creating some confusion. In addition, the team grew significantly in year two, and the meeting structure needs to be revised to fit the current size and configuration of the team members and roles. Further, the center management needs to motivate team members to use the Teams file sharing format.

The center leadership is committed to continuous improvement and to data-driven decision making. The information that emerged from the reporting this year will serve the center well as the leadership works with the team to make the changes needed to address the challenges.

EVALUATION QUESTION 2: To what extent did the MNT-EC reach its intended audience?

Reach refers to the extent to which the MNT-EC has made contact with its intended audience. Reach is important in that it is an indicator of the degree to which the center is successful at bringing its resources to scale. In addition, it can be seen as a pointer toward use of the center resources by stakeholders (used/not used).

In year two, the center participated in conferences, partnered with other NSF ATE centers and projects, and engaged with business and industry and community organizations. The media used for outreach was varied and grew in its diversity. The level of messaging created by the center also expanded during year two. One of the factors for this was the Media Specialist engagement in developing and coordinating the messaging of the center's social media efforts. Media modalities used this year included:

- Talking Technicians podcasts
- Industry immersion and/or faculty workshops
- OER journal: Journal of Advanced Technological Education
- MNT-EC website
- Think Small Blog
- MNT-EC newsletter
- ATE Central
- LinkedIn
- YouTube

The MNT-EC identified the following indicators to measure the reach of activities and initiatives:

1. Individuals reached through outreach and dissemination events and activities
2. Faculty reached through professional development and the MNT-EC network of colleges
3. Industry reached through outreach and training
4. Students reached with MNT-EC materials and initiatives
5. Veterans reached through MNT-EC outreach activities

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 2-year college instructors, administrators and students; veterans, K-12 teachers; career coaches; university faculty and administrators; and employers who hire micro nano technology technicians.

Outreach Strategy

Increasing communication between science communities is a major aim of the MNT-EC. The MNT- EC dissemination plan supports faculty teams to attend on-line meetings, workshops, conferences of science organizations, such as the National Institute of Standards and Technology (NIST) and to share resources and bring information from these organizations to the MNT-EC Community. The MNT-EC outreach strategy is embodied by the purpose statement of the Outreach Working Group:

> ***The Outreach Team is a working group sub-team of the*** MNT^{e}SIG led by MNT-EC and composed of team members from NSF ATE projects and centers, community colleges, universities, and high schools. ***The*** MNT^{e}SIG ***Outreach Team*** strives to encourage member engagement, share resources, provide information, recruit and retain new members, and facilitate networking connections among its members. The MNTeSIG brings together educators and industry partners to raise awareness of micro and nanotechnology resources and education at all academic levels nationally and internationally. The purpose of the outreach activities is to provide information and resources, micro and nanotechnology curriculum, laboratory activities, training, and professional development opportunities for educators and industry representatives.
>
> MNT-EC Outreach Working Group Purpose Statement

With the Outreach Team seeing itself as a subset of MNT^{e}SIG, it is important to note that it became clear this year that, while it is supportive of the center, MNT^{e}SIG is not under the agency of MNT-EC and is not driven by the needs and success of the national center. Rather, it is an arm of SCME (Support Center for Microsystems Education). It also became clear this year that SCME is planning to continue for a number of years, and plans to keep MNT^{e}SIG in its service. Given the importance of outreach to the National Center, having the Outreach Working Group see itself as under an organization that does not have MNT-EC as its highest priority, is less than optimal.

Since MNT-EC funds the Outreach Working Group, it is recommended that, rather than having it as a MNT^{e}SIG Subgroup, to bring the Outreach Working Group under MNT-EC's agency like all of the other working groups. MNT^{e}SIG currently has a conference planning committee, which should remain under SCME. Additionally, the working group reporting-out functions that have been performed under MNT^{e}SIG, should be wholly sponsored and facilitated by MNT-EC. The center could send a single representative to MNT^{e}SIG meetings to report out on its activities overall, disseminate information on the center, and solicit support from MNT^{e}SIG meeting attendees. This would continue the collaboration between the organizations, but put the focus of the working groups on MNT-EC. This would also build on the additional recommendation to hold regular meetings of the working group leads.

Outreach Results

The respondents to the Center Survey indicate that the center remains focused on its intended audience, with 95% of the respondents self-identifying as being from the intended audience. One measure of the center's overall reach is the number of individuals on its mailing list. In year two, it took a big jump from 332 to 3,583, a ten-fold increase. This was a combination of increased registrations on the MNT-EC website (250), and the generous offering of SCME to merge its mailing list (3,000) with that of MNT-EC.

Because of the continued restrictions during the pandemic, all outreach took place on-line. The center actively participated in conferences, with a total of 84 presentations at 28 conferences, tripling its results from last year. As an indicator of the broad range of the audiences, examples of the conferences and events included NSF ATE, ASEE, NCPN, ACTE, AACC, National Association of Community College Entrepreneurship, and professional development workshops sponsored by other organizations.

Overall, the MNT-EC reach in year two was 4,825 educators, students, and representatives of industry and government. Reach occurred through MNT-EC participation in regional and national conferences and meetings; attendance at professional development workshops for educators; webinars; MNT-CURN sessions; students in classrooms, podcast downloads and YouTube views. This represents a 26.5% increase over last year's total reach. The concept of reach as it is distinguished from frequency is discussed later in the report.

Other MNT-EC documentation also indicates that the center had considerable growth in reach to its intended audience, as shown in Table 4 below*.

	Y1	Y2	% Change
Number of students reached by MNT-EC materials & Initiatives	765	896	17.1%
Number of educators supported by professional development	161	208	29.2%
Number of students and educators in outreach conferences	1,526	1,710	12.1%%
*Because many events were on-line and audience characteristics were available for about half of the events, the totals for each audience category were extrapolated, using the percentage of totals for the events that did report on audience segments.			

Table 4: MNT-EC Center Reach, Year 2

The distribution of the audience for MNT-EC outreach and dissemination is shown in Figure 5 below, with comparison to year one. The reach in terms of two-year faculty and K-12 teachers reached in year two increased dramatically. The increase was partially due to an increase in the number of in-person conferences this past year, and partially due to improvements in measurement afforded by the Annual Center Survey.

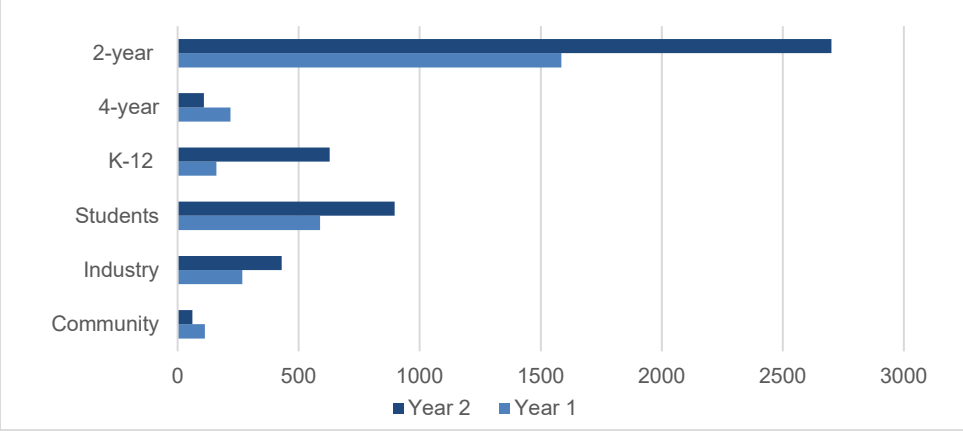

Figure 5: Distribution of Outreach & Dissemination by Audience Category

Reach: Industry

In its outreach events, the MNT-EC reported reaching 382 companies, primarily through two venues, conferences and the Business and Industry Leadership Team (BILT).

The center had booths and made presentations at conferences which had industry attendees. The two largest were the Association for Career and Technical Education (ACTE) and TechConnect. MNT-EC made a presentation at the ACTE conference and had a booth at TechConnect.

MNT-EC put a great deal of effort into recruiting business and industry participants to the BILT and this year recorded 32 BILT members attending its KSA identification sessions and trend meetings, with most

attending more than one session. There were four meetings of the BILT this year, and the first was an industry-only meeting to kick off the BILT in keeping with its intent to be an industry-driven organization. There was one KSA session for micro systems and there were two meetings to discuss trends in micro nano technology. In addition, four industry partners are on the Industry Working Group.

Reach: Educators and Students

Faculty are reached through the center professional development, dissemination activities and through the center's growing network of colleges with micro nano technology programs or with MNT embedded into coursework.

Professional development activities during year three included a Spring Seminar Series and Summer Seminar Series. Participation in conferences and the downloading of podcasts reached the largest number of educators and students. In total, the MNT-EC outreach to educators and students was 4,534 including downloads of podcasts and You Tube videos.

	Y1 2020-21	Y2 2021-22	Change
Professional Development Sessions	161	260	+99
Podcast Downloads	62	1,066	+1,004
You Tube Video Downloads	672	898	+226
Classroom students using MNT-EC materials	n/a	559	
MNT-CURN	n/a	41	
Conferences	1,526	1,710	+184
Total Educators & Students	2,421	4,534	+2,113

Table 5: Faculty and Students Attendance and Downloads

Educator and Student Demographics

MNT-EC does not yet collect enrollment data from its education partners. However, it has a significant program in undergraduate research, the MNT-CURN, with 31 students. In a pre-program survey, students were asked to provide information about the race and ethnicity and gender, and 81% responded. The vast majority of the students, 76.9%, identified as being the first in their families to attend college. The percentage of males was 65.4%. Regarding race, the largest representation in the cohort was African American at 40%, and second was Caucasian, Non-Hispanic at 24%. The overall cohort was 76% people-of-color. The full range is found in Figure 6 and is provided as a benchmark,

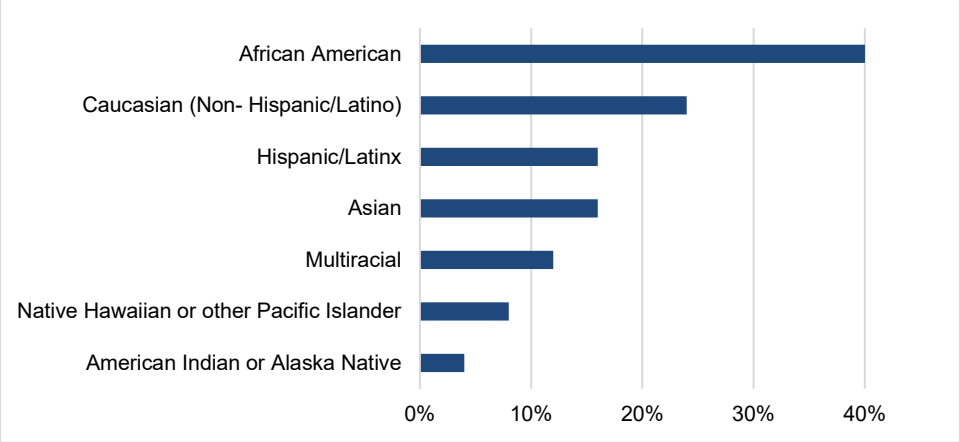

Figure 6: Racial Diversity of Students in MNT-CURN

Educator participants in the MNT-EC professional development were also asked, through a survey, to provide their demographic information. The response rate of the surveys overall was 43.1% (112 respondents), with 84 of the respondents completing the demographics questions. Interestingly, 6.3% indicated that they preferred not to answer.

The percentage of females was 57.6%. Regarding race, the largest representation in educator participants in professional development was Caucasian at 60.8% and second was Asian at 20.5%.

Figure 7 below shows the comparison of the demographics of the faculty who attended the MNT-EC professional development and the students who attended the MNT-CURN. The racial imbalance of instructors and students is one of the issues facing STEM education in the United States in creating inclusive classrooms, and has an impact on the ability to recruit students of color to STEM programs.

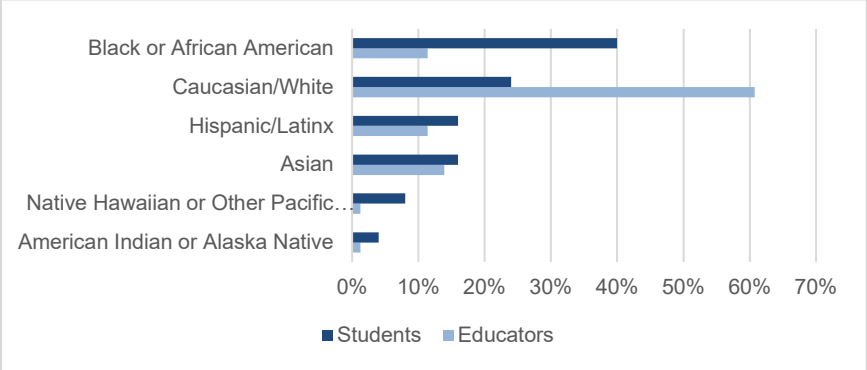

Figure 7: Comparison of MNT-EC Educator and Student Demographics

Reach: Veterans

MNT-EC reported that no veterans were reached in year two. This is the result of a reporting issue that has not been resolved. It is recommended that the center senior leaders work with SUNY-Poly to specify how to identify MNT-EC activities.

Conclusions

In year two the center reached 4,825 individuals (4,534 of which were faculty and students) through outreach events, professional development, podcasts and YouTube, representing a 26.5% increase over year one. The nature of this data, shaped as it is by privacy and IRB restrictions, means that this is not an unduplicated count. While there is likely some measure of duplication, the variety of the channels and the audiences they tend to attract decreases the chance of duplication.

Overall, the MNT-EC is clearly reaching its intended audience in terms of two-year college faculty and is exceeding expectations in reaching students. While its reach of industry is less than optimal, the BILT mentor Ann Beheler has emphasized that building industry participation takes time, often many years. The BILT Lead has engaged with industry leaders one-on-one this year and is working with the PI to leverage the center to gain access to more companies. Further, the center is pursuing an alternative, dynamic database channel for engaging with industry which may gain access to employers more rapidly.

In terms of reach, the number of student participants is exceptionally robust, with the MNT-CURN exceeding its enrollment goal by 65%. Attendees represented eight colleges in five U.S. states and territories. The MNT-CURN was 76% people of color and 40% African American. The center will be applying the same recruitment strategies, reaching out to existing organizations that serve underrepresented students and inviting them to engage with nanotechnology programs.

These results show that the outreach strategy overall is successful in some aspects of the center. However, the center is not getting the results it wants in attendance at workshops. This is the responsibility of the Outreach Working Group, which currently functions as if it is operating under a partnership between MNT-EC and MNTeSIG /SCME. It is recommended that the center bring the Outreach Working Group solely under the management of MNT-EC.

EVALUATION QUESTION 3: What are users' perceptions of quality and relevance of the center's processes and products?

The quality and relevance measures relate to the degree to which center users are satisfied with the MNT-EC activities, products and services. The likelihood that individuals will continue their engagement with the center, including accessing and using the information offered and referring others to the center, are influenced by perceptions of quality.

Quality of the MNT-EC Products and Services

Overall, stakeholders within the target audience perceived the quality and utility of MNT-EC's resources as high. Respondents to the Center Survey rated the quality of MNT-EC resources using a four-point Likert scale as follows: Excellent = 5; Very Good = 4; Good = 3; Fair = 2; Poor = 1.

When asked to rate the overall quality of the MNT-EC resources had accessed in the past 12 months, 62% said they found the resources to be *Very Good* or *Excellent*, and 88% said they were *Good*, *Very Good* or *Excellent*.

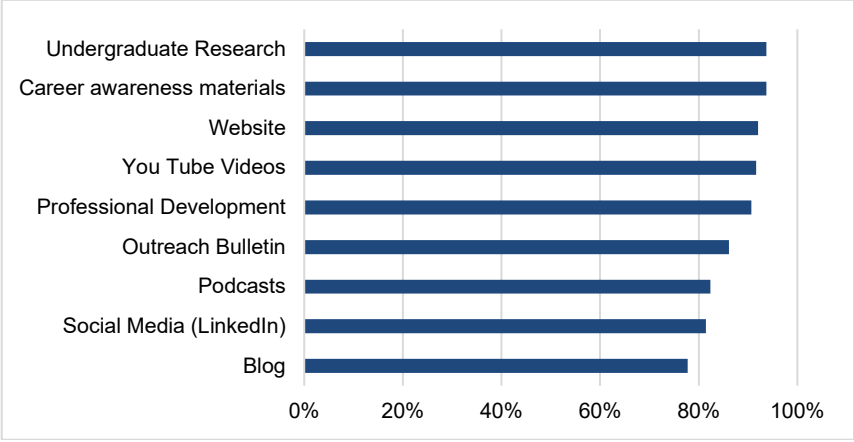

Figure 8: Quality of MNT-EC Resources, Year 2. Percent Excellent, Very Good, Good

The weighted average rating for all MNT-EC products and services was 3.85 out of a possible 5.00, which indicates the center is producing at a high level of quality. No weighted average fell below 3.65 which is between *Good* and *Very Good* for the quality of the center products and services overall. Professional development workshops and the website were rated highest at 4.0 (Very Good). Rated lowest were the social media posts (LinkedIn). LinkedIn posts are just getting started, which may be contributing to the lower ratings.

Professional Development Seminars

There were 15 professional development offerings in year two, in two series offered in the spring and summer of 2021 for 184 participants (compared to 161 one-hour sessions last year). After much planning

and design, the seminars were presented virtually or using remote access. Seminars ranged from one hour to two days (four to six hours per day) in length. Seminars varied in format, with some being almost fully hands-on and experiential, and others being more traditional lecture.

Seminar participants rated the quality of their professional development in terms of the overall opinion of the quality of the session, using the following five-point Likert scale: Excellent = 5; Good = 4; Neutral = 3; Fair = 2; Poor = 1. With 94% of respondents indicating their rating of the quality of professional development seminars was *Excellent* or *Good*, Figure 9 below shows this year's ratings for overall quality.

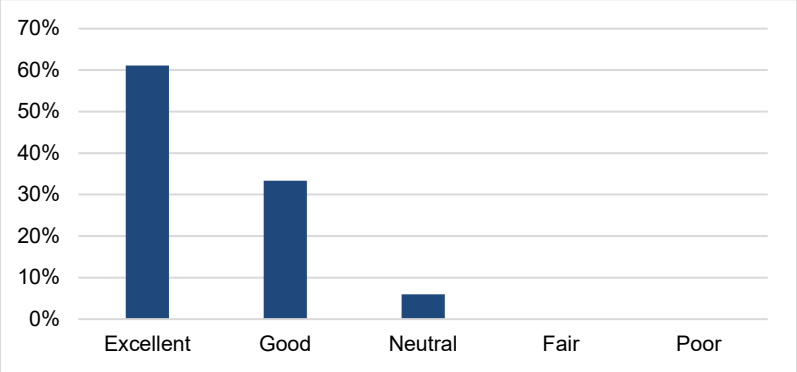

Figure 9: Quality Ratings of MNT-EC PD Workshops

The weighted average of the overall rating of the workshop decreased slightly from 4.68 last year to 4.56 this year, but with both ratings in the realm of Excellent (above 4.50). With the additional variety that was brought to the professional development efforts in year two, the center was still able to maintain quality.

> *The instructor was very patient while explaining, and overall I did gain a lot of knowledge in a very short amount of time. He was great, and very knowledgeable, and that made it easier for me to follow along.*
>
> Seminar Series Participant
>
> *What I found especially good were the Lecture and video order. Having the PP slides available. Plenty of time for questions.*
>
> Seminar Series Participant

Themes that emerged from comments regarding what worked especially well provided evidence that the seminars and the presenters were highly valued by users. Users particularly appreciated the content and topics and the knowledge and competence of the presenters. In fact, when asked about areas for improvement, nearly 40% of respondents commented that they perceived no improvements. The most cited area for improvement was the pace of the lecture and suggesting more time for hands-on experience.

MNT^{e}SIG

The Micro Nano Technology Education Special Interest Group (MNT^{e}SIG) annual conference is co-sponsored by MNT-EC and SCME and was conducted virtually, alongside the NSF ATE HI-TEC Conference. While MNT^{e}SIG is primarily a networking organization for the purpose of fostering collaboration between educators, industry, and agencies, the introduction of MNT-EC in the past two years has moved the event more in the direction of professional development for faculty. In particular, MNT-EC sponsored its consultant in the area of DEI, Dr. Kendrick Davis, to be the keynote speaker on the topic of *The US Scientific Enterprise Through the Lens of Justice.*

A post-conference survey was conducted, in which respondents were asked to rate the quality overall of the conference. Ratings of *Excellent* or *Good* were chosen by 82% of respondents, using a scale of *Excellent, Good, Fair, Poor*. In terms of presentations, the Working Group Pitches and Lightning Round for the working groups received the highest rating at 3.55 out of a possible 4.00. This is a significant decline from last year's top presentation (PI Ashcroft, on MNT-EC) which had a weighted average of 3.74. The keynote speaker, Dr. Kendrick Davis's presentation was rated at 3.50 which was the same as the closing keynote from last year. The average rating across all aspects of the MNT^{e}SIG Conference was 3.48. Importantly, no weighted average fell below 3.30 which is well within the range for *Good*.

As an indicator of value, participants used a Likert scale to rate the likelihood of recommending the MNT^{e}SIG as follows: *Extremely Likely, Very Likely, Somewhat Likely, Somewhat Unlikely and Very Unlikely.* In terms of recommending the conference, 95.4% of respondents were at least somewhat likely to recommend the MNT^{e}SIG Annual Conference at HI-TEC (77% extremely or very likely), which is an increase over last year's ratings.

Additionally, 91.3%% of respondents were extremely or very satisfied with the conference based on a rating scale of *Extremely Satisfied, Very Satisfied, Somewhat Satisfied, Somewhat Dissatisfied, Very Dissatisfied.*

> *"It was much better than many of the virtual meeting I have attended in the past year, well organized and time to chat with colleagues."*
> MNT^{e}SIG Survey Respondent

Proposal Mentoring Initiative

In year two, MNT-EC provided mentoring to eleven individuals working with seven projects in the micro nano technology discipline. In a survey conducted by the center, mentees were asked about the quality of the mentoring they received and, in particular, about the clarity of communications and level of responsiveness. A four-point Likert scale was used (*4=Extremely, 3=Very, 2=Somewhat and 1=Not Very*), and all eight of the respondents (100%) said the communications were extremely or very clear and all indicated the mentors were extremely accessible and responsive to questions.

> "*Greg helped me get 2 letters on short order!*"
> Mentoring Survey

Using a five-point Likert scale (*5= Extremely Satisfied, 4=Very Satisfied, 3=Somewhat Satisfied, 2=Not Very Satisfied, 1=Not Satisfied at All*), all (100%) respondents also said that were extremely satisfied with the aspects of the mentoring they received:

- The MNT-EC mentorship overall
- The communication with the MNT-EC mentors overall
- The timeliness of the feedback and input
- The proposal feedback/recommendations made by the MNT-EC mentors
- The sample commitment letters that were provided

All (100%) strongly agreed that their proposal was improved by the MNT-EC mentors' feedback/recommendations. Further, 100% agreed that they would recommend the MNT-EC mentors to others and that they got the information they needed to submit a proposal.

Regarding the mentors, mentees specifically mentioned their wealth of knowledge and experience with ATE, as well as their honest and kind attentiveness making the grant-writing process seem more manageable and less stressful. Mentees commented that the mentors went beyond advising to true mentoring, including connecting them with potential collaborators and attending meetings with them, finding an external evaluator, finding readers to provide feedback on drafts and making suggestions about goals and budgets.

While all of the MNT-EC initiatives were rated highly in terms of their quality, the proposal mentoring initiative received excellent ratings and praise from users.

> *"My mentor was always available to me to discuss my thoughts, any issues, or answer questions. His wealth of knowledge and experience with ATE, as well as his honest and kind attentiveness made the entire grant-writing process seem more manageable and less stressful."*
>
> MNT-EC Mentee Survey Respondent

Conclusions

User perception of the quality of MNT-EC products and services is very high. In year two, the top-rated products and services were the seminars and the website.

The MNT-EC users reported high levels of satisfaction with the center's initiatives, products and services. More than 94% of seminar series survey respondents rated them as excellent or good (down from 97% last year). All (100%) of respondents to the follow up survey for the proposal mentoring initiative indicated they were extremely satisfied with all aspects of the service they received.

EVALUATION QUESTION 4: To what degree are the MNT-EC's materials and resources being used?

It is useful to distinguish between reach, which was addressed in evaluation question one, and this evaluative question. Reach refers to the extent to which MNT-EC has touched its intended audience. Use of center resources is an indication of the content and the breadth and depth of that contact.

The indicators for this evaluation question are:

- Frequency of use of center resources
- Use of the website
- Use of social media and You Tube
- Use of the bulletin
- Use of podcast

Frequency of Use

Frequency of use refers to how often the center products and services are used. In the Center Survey, respondents used a four point Likert scale as follows to describe their use of MNT-EC resources: Very Frequently (11+ times), Frequently (6-10 times), Occasionally (3-5 times), Infrequently (1-2 times). Figure 10 shows the frequency of use of resources, as reported by the Center Survey.

All (100%) of the respondents used at least one resource in the past 12 months. Center Survey respondents reported their frequency of use of resources within the past 12 months using a 4-point Likert scale: Very Frequently (11+ times); Frequently(6-10 times); Occasionally (3-5 times); Infrequently (1-2 times). The most used resources, in terms of very frequent or frequent use, were the website, career awareness materials and the podcasts.

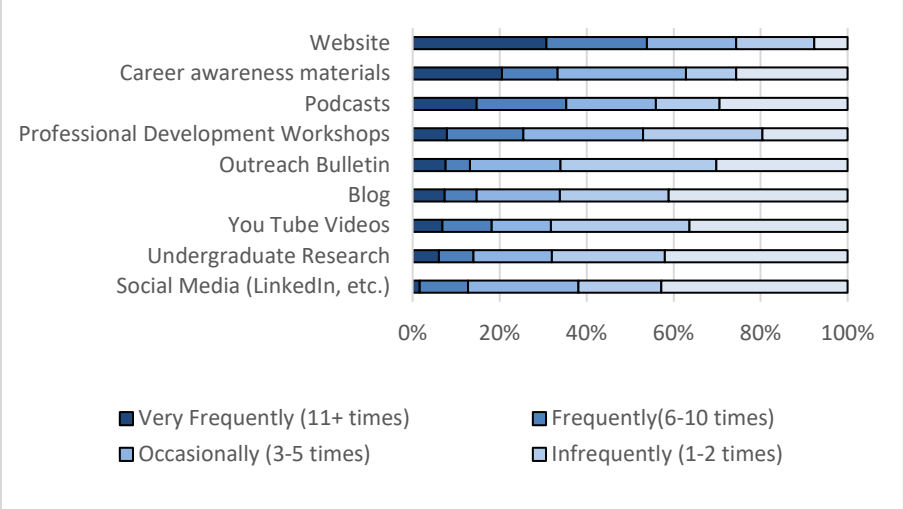

Figure 10: Frequency of Use Center Resources within Past 12 Months

The least used resource in year two were social media posts, which may be expected given that the center did not start posting regularly until the final quarter of the year.

It is notable that one-third of respondents used the website about once per month, with only 20% indicating they never used it. The Outreach Bulletin was published quarterly, and about half of respondents used it once a quarter.

Overall, the frequency of use fell generally in line with that of other centers known to this evaluator.

Use of the Website

The MNT-EC website had only two months of analytics for year one, which eliminates the possibility of a meaningful comparison of year-over-year website data. Nonetheless, the center had a fully functioning and continuously improving website for the whole of year two. The analytics reported here will serve as the baseline for the center moving forward.

Google analytics reported the number of users per day for the past year, ranging from one to 74, and was trending upward toward the end of the year.

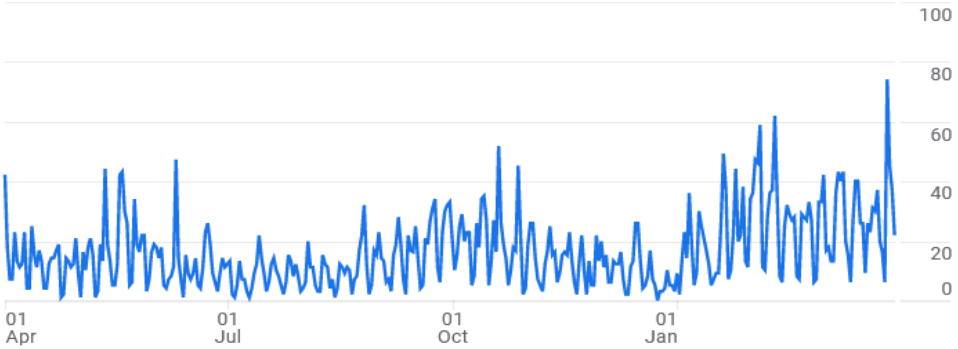

Figure 11: MNT-EC Website Users per Day

	Year 1 2020-21	Year 2 2021-22
Users	n/a	3,738
Page Views	n/a	15,937
Pages per Session	n/a	4.26
# New Users	n/a	3,656
# Returning Users	n/a	774

Table 6: Website Metrics, Year 2

As an indicator that the center's website has been successful and is effective for users, the MNT-EC's first year of web traffic compares favorably to two mature national centers, which are averaging 5,300 users and 13,826 page views per year.

The top web pages with the highest number of views are shown in Table 7 below. These comprise 69% of all web page views. The home page and the pages for the Journal and the Blog were most visited on the site. Importantly the MNT-CURN and the Podcast both qualified as top pages.

MNT-EC Web Page	# Views
Micro Nano Technology Education Center - MNT-EC, including Home Page	3,846
Journal of Advanced Technological Education, including Guide for Authors	2,207
Think Small News Page: Blog	1,264
Calendar - Micro Nano Technology Education Center	762
Students and Parents	760
Educators	738
Micro Nano Technology Collaborative Undergraduate Research Network	527
Talking Technicians Podcast - Micro Nano Technology Education Center	450
Source: Google Website Analytics. Top Web Page = more than 400 views.	

Table 7: Web Pages with the Largest Number of Views

Social Media

Linked In

LinkedIn analytics measure the following:

- Impressions: number of times posts from MNT-EC were seen by LinkedIn members
- Clicks: The number of times the MNT-EC name, content or logo has been clicked.
- Followers: similar to subscribers
- Interactions: the number of likes, comments or shares
- Engagement Rate: interactions as a percentage of impressions

In year two, LinkedIn reported the following analytics for MNT-EC. Three of the posts contained videos that garnered 216 views. Notably, about 2.5% of the center posts led recipients to click on MNT-EC materials.

Metric	# in Year 2
Impressions	2,656
Clicks	60
Followers	25
Interactions	120
Engagement Rate	6.78%

Table 8: LinkedIn Analytics

The content, quality, frequency and coordination of the posts to LinkedIn improved significantly when it became a focus of attention by the Media Specialist midway through year two. Since timing and consistency can help to maximize the effectiveness of the posts to grow the followers, in year three it is recommended that the center establish specific targets for the number of impressions and interactions it will achieve, so that the specialist has clear goals.

You Tube

The MNT-EC channel contains 41 videos and has 102 subscribers (see Table 9). In year two, the center nearly quadrupled the number of videos posted to the site and nearly doubled the number of subscribers, creating 100 more views than last year.

	Year One 2020-21	Year Two 2021-22
# Videos	12	44
# Subscribers	55	102
# Views	802	898
# Viewing Hours	38.8	43.2

Table 9: You Tube Analytics

The highest viewed videos are:

1. ATE Student Success Stories – Paula. #1 again this year with 354 total views, up from 194 last year)
2. Nanotechnician and Advanced Materials technology, Neda Habibi 215 views
3. Nanotechnology Education: An Interview with Jared Ashcroft (183 views, up from 122 last year)
4. Kendrick Davis, STEM Equity - the MNT-EC (106 views, up from 59 last year)

Bulletin

In August 2021, the center began to produce and disseminate a quarterly newsletter, the MNT-EC Bulletin. They included a message from the PI, Jared Ashcroft, Upcoming MNT-EC Events, Upcoming Conferences, Great Opportunities for Instructors and Students in Micro Nanotechnology, Articles of Interest and Videos and Podcasts of interest. The three bulletins were sent to an average of 520 individuals and on average, 27.8% opened the bulletin (which is in line with similar ATE centers).

Some concern has been expressed that information is not timely enough, with much of it either too early or too late for people to get events into their calendars. The center is moving to automate the newsletter through the website and to send it out more frequently.

Podcast

The Podcast is released on all major Podcast listening platforms such as YouTube, Apple Podcasts, Google Podcasts, Spotify, iHeartRadio. It is also incorporated into the MNT-EC website and each podcast episode can be heard from there through the Buzzsprout Embed Player. The center reported analytics for the website and YouTube and those metrics are shown below in Table 10.

Top Podcast Players*	Percentage of Downloads	Total Downloads
Buzzsprout Embed Player (the MNT-EC)	74.6%	795
YouTube	25.4%	271
Total	100.0%	1,066
*Additional podcast players include Deezer, Spotify, Amazon Echo		

Table 10: Podcast Players

Conclusions

During year two, the website was by far the most frequently used MNT-EC resource, followed by career awareness materials and podcasts. Given that this is the first full year for the website, it is notable that its traffic was significant, and equal to or greater than that for other, more mature national centers.

The jump in number of downloads of the podcasts was a big success. The podcasts were well-promoted thanks to the efforts of Co-PI Kazarinoff's consistent efforts to remind people of the podcasts and for posting the link in the chat of every ATE-related Zoom session he attended. The expansion of the role of the Media Specialist, with his focus on posting to social media, could bring similar results for the Bulletin and You Tube videos in the coming year.

EVALUATION QUESTION 5: To what extent did the center's work lead to systemic change regarding the education of the micro nano technology workforce?

The overarching purpose of most, if not all, of the activities of the MNT-EC is to increase the capacity of the United States to meet the need for nanotechnology technicians across the country. Systemic change is a long-term proposition, and measurement is challenging. However, some actions by the PI and some initiatives by the center have early indicators that they are leading toward systemic change:

- Leveraging the sway of the National Center to influence how community colleges and industry work together to address the current shortage of microchips and projected need for technicians
- A strong emphasis on minority participation in the center's undergraduate research experience project
- Podcasts spotlighting micro nano technology technicians who are from minority populations
- Inauguration of a Journal of Advanced Technological Education
- Direct and pointed outreach to produce more ATE proposals in MNT
- Capacity Building

Advocacy for Innovative Collaborations in Semiconductor Technician Education

PI Ashcroft made numerous presentations, both formal and informal about changes needed to the way community colleges are approaching development of microchip manufacturing programs and recruiting students to attend them. The current environment, with its well-publicized shortage of microchips has led to the announcement for three major manufacturing facilities in the U.S., with more likely to come. This puts a spotlight on the need to greatly speed up additions to the microchip technician workforce. PI Ashcroft is advocating for change in how the system components relate to one another.

As community colleges are moving to meet the need, PI Ashcroft noted that the effort is largely disjointed and less effective than is required at this pivotal time. He presented his vision for how to proceed, to colleges, universities, businesses and not-for-profit organizations. His vision includes collaborations between universities, industries and community colleges and getting out of existing silos to create a cohesive recruitment strategy that focuses on both students in transfer programs and students in technical education associates degrees that lead directly to industry jobs.

This will require getting the research universities to agree that academic pursuit is not appropriate for all students, and industry to agree that four-year degrees are not required for all technical work. And, it will require moving away from that paradigm toward one creates programs to teach those students

semiconductor manufacturing principles, technician principles and get them a job. Additionally, programs need to start much more impactfully for students so they are involved in hands-on, problem solving early in the program and the required theoretical concepts are presented after or concurrent with that so students see how it is applicable.

In PI Ashcroft's vision, this leads directly to apprenticeships and internships which need to be much more widely available and funded. Industry has not stepped up in terms of paid apprenticeships and internships to the degree that is needed. The students who are excellent candidates for technical education and jobs often lack the resources to attend college full time. This reduces the number of individuals in the pipeline, at a time when it needs to be maximized.

Dr. Ashcroft's concept is to build on the one-off webinars and events that have been taking place across the country and create a semiconductor summit over the next six months starting in September, with community college faculty and an industry partner giving an on-line presentation once a month, to share what's working and not working. This would culminate in an in-person conference with facilitated discussions on next steps for community college technical education programs.

The overall theme of Dr. Ashcroft's advocacy is that this is a systemic issue that cannot be solved in one-off sessions and discussions. What is needed is months of discussion and years of coordinated actions toward long-term solutions. The MNT-EC Center will be engaging in this and will invite other organizations such as SEMI and its foundation, and the American Semiconductor Academy (ASA) to join in this endeavor. It is too early to know the outcomes of this advocacy; initial indications will be available in the coming year.

Attracting and Welcoming Traditionally Underserved Students to MNT-EC Undergraduate Research Experience

In the initial weeks of the first-year pilot of the MNT-EC Undergraduate Research Experience (MNT-CURN), PI Ashcroft saw that traditional outreach was not producing the minority participation that his proposal emphasized. He and the MNT-CURN Co-Lead, Dr. Kendrick Davis, reached out to Dr. Jalil Bishop, CEO of the MUME Collective, Inc. to develop an assessment strategy focused on DEI. This led to recommendations for the center to shift its approach considerably. Dr. Bishop and Dr. Davis led an initiative to build out new partnerships with existing networks for students of color. For example, the center worked not just with the Community College of Philadelphia but also partnered with their Center for Male Engagement whose mission is to support male students of color on campus. This partnership ensured that MNT-CURN was able to connect with a program that already had the trust and participation of students of color along with support staff to help students take advantage of opportunities at MNT-EC. The result was that over 90% of the students in the URE program are from underrepresented groups, representing eight community college campuses in five states.

This approach is transformational in that its starting point is existing student organizations that support underrepresented minorities and bringing the program into their existing framework, as opposed to establishing a program and then inviting underrepresented students into it. This manner of recruiting underrepresented minorities is being adopted by the MNT-EC center overall, moving beyond the MNT-CURN program. In year two the center worked with Pasadena City College (PCC), Fingerlakes Community College (FCC), the Community College Undergraduate Research Initiative (CCURI)) and Community College of Philadelphia (CCP) to build out their capacity not only to participate in MNT-EC's program but also form their own diverse STEM pipelines on their campuses.

Further, MNT-EC is inviting discussions around DEI in STEM with community college partners and the broader ATE community in an effort to increase recruiting and making more students aware of advanced

technological programs. For example, PCC, FLCC and CCP have formed a coalition of STEM faculty and are preparing to apply to grants to support their work. In addition, CCP will be added as a subaward on the MNT-EC grant to develop a nano/biotechnology program and an ATE proposal that looks to provide a multi-disciplinary program that recruits from the Center for Male Engagement and other student organizations that support underrepresented students.

Podcasts

When the center began this project, the podcast world was not being used broadly for the academic environment. As podcasts began offering more credible and valuable information, they have emerged as a quality platform to disseminate information and opportunities.

The *Talking Technicians Podcast* consists of interviews and dialogues with working technicians from underrepresented groups who graduated from a two-year technical program. It covers the journey to their current job, where they started and their experience in the present time. As such, the podcast serves the workforce education system as a whole. It sets a tone and model for other podcasts produced by ATE centers, projects and community colleges to prioritize the visibility of under-represented groups. In addition, the stories, viewpoints and journeys of the diverse set of technicians on the podcast can be relatable for future students. Also – at least one faculty member has said they will use the podcasts as part of their curriculum in the coming year.

The center released 14 episodes in the reporting period for year two (compared to five in year one), generating 1,066 downloads. In addition to gender and racial diversity (which were a focus in year 1), the podcast interviewed diversity in age and diversity in professional technician experience during year 2, specifically women, Latinx, first generation college, immigrant, single-parent, Veteran.

The *Talking Technicians Podcast* is targeted to individuals who are considering a career in technology but are not quite sure if they fit the requirements. The purpose is to break down those barriers by sharing success stories of people to whom listeners can relate, with the goal that they will gain confidence to take the first step and enroll in a STEM course or program at a two-year community or technical college. A secondary audience is faculty at community and technical colleges who can learn what their students do in the workforce after they graduate. Additionally, it may impact students who identify with one of the guests and strengthen their resolve to enroll in or complete an MNT-related program of study, and may impact employers who can broaden their concept of MNT technician. While the impact is difficult to measure, the center could strategize to identify indicators of success and methods to collect applicable metrics.

Anecdotally, there have been discussions about how the podcasts can be used to enrich curriculum. Further, a speech writer for the National Science Foundation reached out to the podcast for contact information and to confirm statements made on an episode to incorporate into a speech by one of the NSF Leaders. Also, Co-PI Kazarinoff was interviewed about the podcast stories by the National Nanotechnology Initiative (NNI), U.S. Government research and development initiative.

Additional evidence of movement toward systemic change has come through the NSF ATE Biotech Center (InnovATEBIO) as it expressed interest in podcast episodes or a series with bio technicians. In addition, Comments from community college faculty and staff that mentioned that it might be more engaging to see as well as hear technician stories. As a result, next year the podcast will explore interviewing technicians from other disciplines outside micro/nano and recording video as well as audio in each episode and upload it to YouTube.

Accessibility

PI Ashcroft is committed to making all of its content accessible and has impressed the importance of this with the Center Team. CAST was added as a partner to provide consultation on how to implement accessibility into the workshops and presentations and ultimately into MNT classrooms. In year two, the primary work with CAST was with the MNT-CURN, and the development of an accessible MNTFolio. CAST provided an introductory training session for students and mentors that provided three challenges. These challenges afforded students and mentors the opportunity to get to know the platform and the format, and also to pilot the format and provide feedback. The MNTFolio provides an effective initial entrance into MNT education and can provide a platform for students to demonstrate technical MNT knowledge and skills along with employability skills that can be easily shared with industry.

The MNTFolio has the potential to become another national initiative, as centers including NCAT, InnovATEBIO, NCyTE, and Next Generation of Advanced Manufacturing Centers have indicated an interest in building their own folios through a partnership with CAST and in working together to develop cross-disciplinary folios.

In year one, CAST provided a virtual seminar on how to make webinar presentations and materials accessible to all participants. It is recommended that next year, MNT-EC consider having CAST offer a follow up seminar to review and dive more deeply into their Universal Design principles as they relate to webinars and classroom presentations.

Journal

The Journal of Advanced Technological Education is the first peer-reviewed journal specifically for ATE projects and centers. From its inception, the vision was to create a publication to address the absence of a peer-reviewed journal for community college faculty and instructors.

Originated by MNT-EC, it started out as the Journal for Micro Nano Technology Education, and year two was nothing less than momentous for the journal. The creative thinking and the potential of the journal were readily perceived by the InnovATEBIO and NCAT centers, and PI Ashcroft saw that the scale, reach and impact of the journal would be enhanced by opening it to other disciplines. As a result, by the end of its second year, the journal is a national project and includes editors, reviewers, authors and workshop learners from across the country and encompassing all of the subject disciplines covered by ATE. It has the support of the five large new ATE Centers: MNT-EC, InnovATEBIO, NCAT, NCyTE, the EARTH Center and NCNGM.

In addition to vastly expanding its content area, the journal accomplished a major milestone this year in the release of its inaugural issue, consisting of five articles and seven invited letters, and published on the MNT-EC website at Volume 1 Issue 1 – Micro Nano Technology Education Center (micronanoeducation.org). Further, the journal reached seven significant milestones in year two[2]:

- Editorial Board was formed
- Editor-In-Chief was selected (Dr. Peter Kazarinoff, Co-PI), along with three associate editors selected by the Editorial Board
- The submission and peer review process was implemented and revised as the board gained experience with the process
- Writing workshop for faculty was offered
- Writers Group and Reviewers Group were initiated and each meets monthly

[2] An interesting note is that during year two, J ATE rejected its first article. It was noticeable that the article came from authors not associated with the ATE community (so somehow they heard about the Journal, sought it out and submitted an article). The article was rejected due to plagiarism issues.

- The planning, personnel and budget to print and distribute the first issue in hard copy form were established; MNT-EC is fully funding the first print issue. .
- The Journal Web Team created the first issue interface making all articles available for free on the J ATE website with PDFs of each article available for download.

The Editor-in-Chief reached out to Mentor Connect and the EvaluATE Center to work on institutionalizing writing journal articles into ATE project proposals and use of evaluation data from ATE projects to produce articles. In addition, the journal is co-sponsoring the co-branded bags and pens, and providing a hard copy of the Journal's first issue for each participant at the HI-TEC Conference in July. These outreach activities are an effort to get out ahead of two challenges that the journal anticipates: a sufficient flow of article submissions and a sufficient number of reviewers. The review process is expected to be used as an introductory tool to the journal for the current reviewers who are anticipated to be the possible authors of the future issues.

Dr. Ismail Fidan, Professor of Manufacturing and Engineering Technology at Tennessee Tech University was added to the J ATE team, first as a visiting editor and then selected by the Editorial Board to become an Associate Editor of the Journal. Dr. Fidan's work with the journal was a significant unanticipated boost during year two. He came to the journal with deep and broad experience in editing and publishing esteemed national peer-reviewed journals in STEM fields. Dr. Fidan worked on soliciting articles, advising on the journal's peer-review process, participating in the Readers and Writers Group monthly meetings, assisting with DOI and ISSN numbers and in countless other small ways.

Both reviewer and author workshops held by the Journal Committee members play a significant role in the transformation of the community and technical college faculty members into active contributors not only to J ATE but hopefully to the literature in general. The ultimate purpose of the journal has been to educate the faculty in professional technical education to help them follow the ongoing innovations in advanced technological education and to encourage them to become active contributors to the literature in the form of publications. The literature can serve as a platform for the exchange of ideas, discussing them to the fullest extent. J ATE values its role of being such an enabler for the community and technical college STEM faculty as its highest priority and its foremost area of impact.

Evidence of impact includes the expansion of the mission of the journal to encompass all disciplines funded by NSF ATE, and a growing interest and momentum for the journal leading to community-wide support. The Center Executive Team has observed meetings and events, in which the journal has been brought up by PIs, center directors, program officers and others not directly involved in the journal, without prompting. The journal was included in the NSF DUE NEWS Digest (Vol. 3, No. 4, March 28, 2022) which covers all of the Division of Undergraduate Education at NSF and is a rare occurrence for ATE endeavors.

The Editor-in-Chief has been approached by a leaders in the ATE Community to write letters of commitment for a future proposal for the J ATE to have its own funding stream. The journal will eventually move to an online peer-review system and eventually move to its own publishing platform outside of the MNT-EC website. Like Mentor-Connect, ATE Central, and the HI-TEC Conference, J ATE cuts across all disciplines in the NSF's ATE Program and has the potential to be a signature project in the ATE community.

Growing the Number of ATE Proposals

Proposal mentoring is a major initiative for the MNT-EC's goal to create systemic change in the micro nano technology workforce system, and the systemic impact was apparent in year two. A unique co-mentoring model has been created in collaboration with Mentor-Connect, and it has been replicated by other national centers. This model is unique because it actively partners Mentor-Connect mentors with a Subject Matter Expert (SME) in micro nano technology. In the past, mentees had mentors who were focused on proposal preparation; however, mentees had to rely on their own expertise for the technical content of their proposal. Now, the two groups, mentors and SMEs, work together with mentees to prepare and submit a project proposal. As part of the co-mentoring model, mentors from MNT-EC, can also serve as Mentor-Connect mentors.

The impact on the system of the co-mentoring initiative goes beyond a successful proposal submission. The training and mentoring that MNT-EC mentees receive is a form of professional development in growing and developing programs. Even more, the networking that has resulted from collaborations developed for purposes of creating a proposal will likely be institutionalized and will continue to exist.

MNT-EC is also actively encouraging underrepresented faculty and minority serving institutions to develop and submit ATE proposals. Co-PI Cossette is driving the development of a database of two- and four-year institutions with the MSI designation that offer nano or nano-related courses or programs. All MNT-EC working groups will be able to utilize this database, and it will be used to strategically identify potential mentee institutions. The development of the database is behind schedule, but is on track to be completed early in year three.

Year two also saw process improvement in proposal mentoring, including the use of a dedicated page on the MNT-EC website that disseminates information and includes an on-line application form. Further, the center is working with Mentor-Connect to encourage all proposals to include submission of articles to the Journal of Advanced Technological Education. In year two, seven proposals were submitted under the MNT-EC-Mentor-Connect co mentoring model, with two receiving funding and two pending.

It turns out that a significant portion of the mentorship effort is increasing the outreach efforts to colleges and non-profit organizations to recruit more organizations to submit proposals.

> *"The mentors Mr. Greg Kepner and Ms. Mel Cossette were very helpful in every step in the proposal writing, they connected me with possible collaborators, and attended the meetings, and went the extra mile in reviewing the proposal and suggesting edits and additions. The input from the mentors was significant and very effective. The proposal would not have been submitted without the help of the mentors."*
>
> MNT-EC Mentee Survey Respondent

Micro Nano Technology Community

A significant component of the broad system to educate MNT technicians is the ATE MNT community. The community is storied to have started in 2011 when six centers at the time partnered to start an annual MNT Conference. The location of the conference rotated amongst the centers—SCME, NACK, Nano-Link, NEATEC, SHINE, and MATEC. In 2017 SHINE hosted the MNT as a Special Interest Group conducted in conjunction with HI-TEC and starting in 2018 SCME permanently took on the coordinating function for the conference which has been held at HI-TEC ever since. The conference name was changed to MNTeSIG and is now under the auspices of SCME.

Out of that multi-year collaboration, a community grew, made up of faculty, administrators, industry and students. By 2019 when the MNT-EC grant was submitted, many of the former centers were sunsetting or

preparing to sunset, and the formation of the MNT-EC Center was a further collaboration to formally coalesce the community under one umbrella.

In year one of the center, there was an enthusiasm for seeing this idea come to fruition; however, year two saw the emergence of some challenges. With hindsight, as might be expected, the PIs, Co-PIs and core staff of the subsumed centers had more loyalty to their existing and former entities than anticipated. Many are leads for the MNT-EC working groups, and, with some exceptions, the productivity of the working groups has not been as robust as expected in year two. Rather than the individual centers serving the larger national center, the national center resources have been more often used to promote and enhance their individual projects and initiatives. Because of this, the MNT-EC efforts on a national basis are more fragmented than this evaluator would want.

The Professional Development Working Group provides a good example of this. The working group has 47 members, met monthly (with 15-25 attendees, well-organized meetings, and agendas). The WG reported the following outcomes in their year-end report:

> Year 2 PD opportunities via MNT-EC were not as robust as the previous seminar series year.
>
> Multiple PD activities are captured and advertised via MNT-EC. Some examples for these are:
>
> - NACK's NSF ATE funded:
>   1. Introduction to Nanotechnology Workshop for Educators that ran for 2 hours on Fridays for six consecutive weeks from late January to early March.
>   2. Nanotechnology Educator Topical Seminar (NETSS) Series: Leveraged presenters from across the MNT PD WG to provide sixteen 2 hour topical seminars (8 in the spring 2021 and 8 in the fall of 2022). The NETS series seminars were recorded and are now available as resources for educators via nanoHUB.
>
> The NACK PD Team created the Implementing Nano Working Group (INWG) experiment. A High School Team INWG and Undergraduate INWG led by experienced members of the MNT national community will commence in mid-March.
>
> Professional Development Working Group Annual Reporting

Figure 12: Excerpt from PD Working Group Year End Reporting

It is concerning that they reported on what they called the NACK PD Team activities for the MNT-EC PD Working Group. It seems that the two have been conflated. In addition, the emphasis here is on the support that MNT-EC provided to NACK in year two. As an MNT-EC working group, funded through subaward by MNT-EC, and especially with the expanded subaward to NACK, this evaluator would expect to see the working group focused on and producing MNT-EC outcomes.

There are similar examples for many of the working groups, some more than others (see Outreach Strategy section of this report). The MNT community per se is not the issue. Rather the concern is that the role of the community, the role of the MNT-EC center, the roles of the working group leads and the boundaries, tasks, and expectations of the various community members seem to be muddled. In important ways this is watering down the center's efforts and reducing the potential impact of MNT-EC in its own

new, innovative directions for systemic change regarding the education of the micro nano technology workforce. It will be important to address this at the end of year two while the structure is still relatively pliable.

It is also important to note that members of the micro nano technology community are highly experienced professionals in the micro nano technology sector and in micro nano technology education. Many have worked together in other organizations and have well-established relationships. This makes for a strong and mature team in which can communicate as needed to address the issues that emerged in year two.

Capacity Building

The center has designated building the capacity to educate micro nano technology technicians as an indicator of systemic change. In addition to the initiatives listed above, the center has activities that are designed to increase the capacity of the system to educate technicians. Consistent with the MNT-EC logic model, it is theorized that an outcome of the center's work is an increase in knowledge and understanding of micro nano technician careers, education, and workforce development, which increases the capacity of the system to attract, educate, and hire micro nano technicians. Four indicators of the capacity to educate micro nano technicians are as follows:

- Building programs in micro nano technology
- Curriculum and distance education
- Impact on educators and classroom practice
- Impact on institutions (no data yet)
- Impact on students
- Impact on the workforce development system

Building Programs in Micro Nano Technology

The results of the Curriculum Working Group in the area of supporting new micro nano technology programs were very successful in year two. MNT-EC hired a consultant, Marco Curelli, to support the development of a nanotechnology programs across the US. The Center, through PI Ashcroft, Co-PI Habibi and Consultant Curelli[3] provided support and mentoring to four community colleges[4] to start or improve their nanotechnician programs. Support included providing nanotechnology curriculum, introductions to centers of influence, and help with strategy and design. In year three the center plans to disseminate the content it has accumulated from center partners or developed through the working group to more MNT programs.

Year two also saw the initiation of a MNT-EC community of practice (CoP) consisting of colleges that have, or want to offer, micro nano technology content to students. Over the course of the year, nine colleges met on a monthly basis to share best practices and discuss challenges in offering MNT certificate, associate's degree and bachelor's degree programs at community and technical colleges.

The CoP has the potential to increase the level of collaboration between college programs in MNT in order to build a network to support new programs to come on line and to strengthen existing programs. In year three, participants will be asked to rate their experience of the CoP and any impacts they have observed.

[3] Marco Curelli is CEO of Omni Nano, a nanotechnology education non-profit that develops materials for teach nanotechnology.

[4] Southwestern College (San Diego County) and Santa Barbara Community College, Northwest Vista College and Pasadena City College

Curriculum and Distance Education
The MNT-EC aims to curate common curriculum for associates and certificates degrees for the micro-nano technologies and to promote and support the use of distance education in micro nano technology education. The curriculum and distance education initiatives are guided and produced by the working groups, and there is a two-pronged approach: 1) Development of courses and content and 2) Support of programs.

Development
The results in the area of curriculum development are taking longer than anticipated. The Curriculum Working Group determined that the best start for its mission was to develop an Introduction to Micro nano technology course with ten modules. In year two, the Curriculum Working Group developed five of the ten modules, in part using materials from SCME and NACK. It is waiting for content from Omni Nano, a nanotechnology education non-profit that develops materials for teach nanotechnology. It will be year three before the Introduction to Nanotechnology modules are complete. However, a significant milestone was establishment of Canvas at PCC as the national distribution platform, through efforts of PI Ashcroft. In addition a gap analysis of the existing curriculum was conducted using the KSAs from the MNT-EC BILT.

In the area of distance education, the center made good progress in development in year two, with the focus on connecting two colleges that have distance education infrastructure in place: Rio Salado College in Arizona and Normandale Community College in Minnesota. In year two, the center supported a pilot project to co-enroll students in MNT classes at the two colleges. Rio students were able to take vacuum systems classes via distance education from Normandale. Ideally, this pilot from the Rio Salado grant will be able to be replicated and scaled up through the national center.

Support
The results of the Curriculum WG in the area of supporting micro nano technology programs were more on track, and were significant, as described above with the mentorship of four community colleges regarding MNT programs.

The work of the distance education Working Group in the area of support was excellent, and was a demonstration of systemic initiative. Rick Vaughn, distance education Working Group Lead's initiatives were in alignment to those of the advocacy efforts of the PI to make community colleges central to the training and education of microchip technicians. The distance education Working Group was at the forefront of conversations to promote distance education as one of the options to meet need for increased numbers of technicians. The working group also reported having a strong voice in promoting distance education as a way to diversify the technician education talent pipeline.

Further, the distance education Working Group worked with the MNT-EC Veterans Initiative to use distance education to support military pathways into technician jobs for MNT. These efforts of the distance education Working Group have already produced systemic change and the center is positioned to leverage this for further change in the years to come.

Educators and Classroom Practice
Several of the core initiatives of the MNT-EC are dedicated to making an impact on educators and classroom practice. In year two, the center had measurable impacts in faculty learning and in changes in classroom practice.

Faculty Learning

Consistent with the MNT-EC logic model, it is theorized that an outcome of their work is an increase in faculty knowledge and understanding of micro nano technology concepts, teaching methods, careers, and workforce development translates to improved student learning.

The primary modality for faculty learning in year two was the MNT-EC Seminar Series. Surveys asked participants about new information they gained from attending the seminars offered in year two. All (100%) indicated that they learned new information. In terms of knowledge gains, instructional resources were recognized by the highest number of participants (63%).

In aggregate, participants reported an increase in knowledge and understanding for all topics (Figure 13) with the weighted average rating for level of knowledge increasing from 2.16 to 3.29 across all seminars.

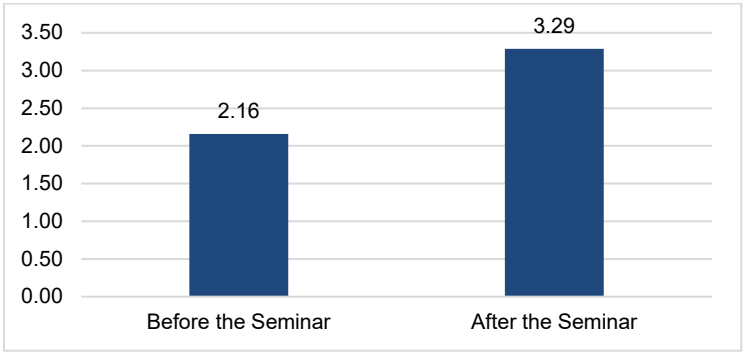

Figure 13: Increased Level of Knowledge from Attending MNT-EC Professional Development Seminars.

The largest increases in knowledge and understanding reported by seminar participants took place in two of the 16 seminars offered. The top four largest increases were from the session titled *Journal of Micro nano Technology Education:*

1. Author guidelines and how to access them
2. The benefits of launching a journal in micro nano technology education
3. Open access publication
4. The topics covered in the journal

The next two highest increases were from the Micro- Nano-Technology Health & Safety session:

5. How to apply MNT health and safety principles .
6. Preventing exposures to MNT particles

The complete list of session concepts and topics is found in Appendix 4.

Classroom Practice

Center Survey respondents indicated how they used the MNT-EC resources in the classroom (Figure 14). All of these actions increase the capacity to engage and educate students in micro nano technology classrooms. MNT-EC resources were used most by respondents to develop or improve lectures, labs and student projects. This has been the center's focus in the first two years, and it plans to bring greater focus to implementing new courses and programs as well.

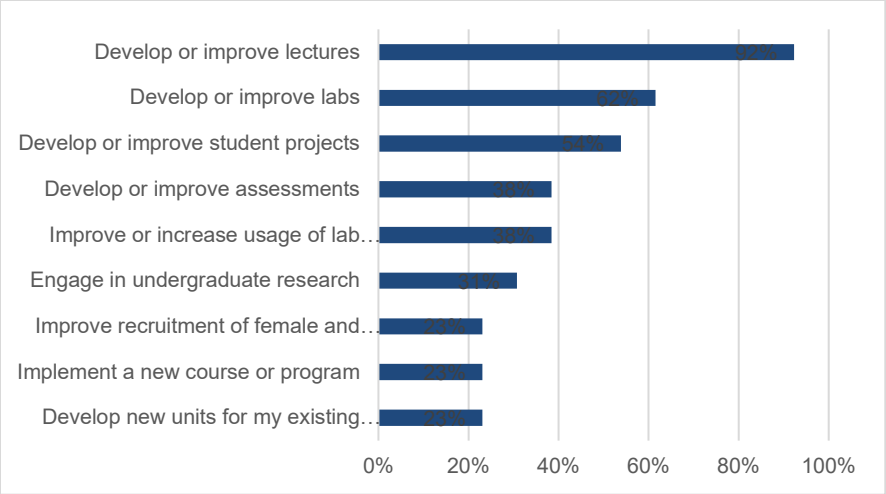

Figure 14: Use of Center Resources in the Classroom. (Source: Center Survey)

Respondents also reported on the outcomes created by their use of the center resources. The Center Survey asked center users to rate the degree to which they agreed with statements about outcomes from using center resources. They used a five-point Likert scale for their ratings: Strongly Agree; Agree; Neutral; Disagree; Strongly Disagree. Figure 15 shows the responses from all completed surveys. More than 60% of respondents strongly agreed that their use of center resources brought improvement in student outcomes, provided new techniques or approaches to teaching and guided more students into micro nano technology careers.

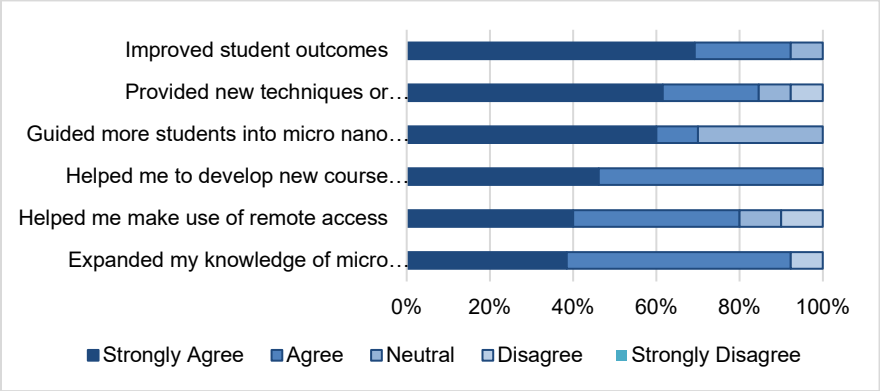

Figure 15: Impact on Faculty of Use of MNT-EC Resources (Source Center Survey

Collaboration with Industry

In year two, the center continued to develop its plan to create a repository of resources documenting industry positions, academic MNT programs and newly graduated technicians and coordinate academic, government, and industry efforts to implement the wide dissemination of that resource.

To build its industry partnerships, the center is engaging the BILT model, which has proven to be successful for other ATE projects and centers. However, MNT-EC is finding recruitment of industry to the BILT and its meetings to be challenging, in that it requires cold-calling and other time-consuming outreach activities which are producing results more slowly than is needed for the level of growth that MNT-EC wants and needs. The focus of the BILT is to engage with employers to produce industry-driven knowledge, skills and abilities upon which to build and update curriculum.

In year two, the Industry Working Group leads began meeting with NIIT (National Institute for Innovation and Technology) regarding their dynamic database of required job competencies, continually updated by industry and built off the SEMI-Works platform. The center is working with NIIT to identify how the competencies in the NIIT model overlap and/or align with the MNT KSAs developed so far with the BILT model. With its platform based on advanced data analytics, and using real-time information from both employers and job seekers to build its content, NIIT has the capacity to move forward more much more rapidly than the BILT model.

Specifically, the center is seeking to determine if the NIIT portal can:

- Provide students with direct access to SEMI and Microsystems related jobs as well as a way for students to document their working skills, subject matter knowledge and employability (soft) skills.
- As a resource for ongoing input from industry regarding competencies as required by industry.
- A method of cataloging training and educational program competencies.

The NIIT system, if successfully implemented and supported, has promise to provide a platform for students, training/education providers, and industry to cross-list their attributes so that job seekers can find jobs and education programs and companies can find skilled workers. It may also provide a constant feedback loop regarding competencies, between education and industry to continuously improve offerings to students. The Industry Working Group is looking at how MNT-EC can best take advantage of the strengths of both the NIIT and the BILT models.

Virtual/Augmented Reality

The MNT-EC is working with NCAT on bringing VR/AR into nanotechnician classrooms. In year two, as a co-sponsor of MNT^{e}SIG, the center it designed and piloted an AltSpace Universe for students and faculty to utilize as a conference space and to present their work.

Wide use of VR/AR in community and technical college MNT classrooms would be revolutionary, and MNT-EC and NCAT are engaged with CA^{2}VES in that endeavor, which is still in early stages.

Conclusions

The degree of impact on systemic change regarding education of the micro nano technology workforce was indicated through eight MNT-EC initiatives in year two:

- Leveraging the sway of the National Center to influence how community colleges and industry work together to address the current shortage of microchips and projected need for technicians
- A strong emphasis on minority participation in the center's undergraduate research experience project
- Podcasts spotlighting micro nano technology technicians who are from minority populations
- Accessibility
- Inauguration of a Journal of Advanced Technological Education
- Growing the number of ATE proposals in MNT
- Micro nano Technology Community
- Capacity Building

All of these had elements of innovation and creative approaches to advanced technological education that were noticed by other projects and centers in the ATE community. They began to consider partnering with MNT-EC and adopting or adapting these innovations, thus already bringing change to the system by the end of year two.

First, the center is taking the lead to change how industry, two-year and four-year institutions relate regarding preparation of the technical workforce. In the coming year, MNT-EC will take the lead in conducting six months of discussion, potentially leading to an in-person conference to see what is possible.

In addition, the center pivoted in its outreach to attract underrepresented students to its activities, to partner with and provide support for existing organizations that serve underrepresented students, and to adapt its programs to those existing frameworks. Over time, if this proves successful, it will be taken up by other projects and centers and will transform how organizations are recruiting underrepresented populations into STEM.

Similarly, the podcasts form a new way to reach potential technicians, and attract underrepresented students to micro nano technology and STEM programs and careers who may be interested, but don't see a path forward for themselves.

The creation of the MNTFolio, an e-portfolio to showcase student knowledge and skills using Universal Design principles will be made available to all projects and centers and is being designed to work for any discipline.

The J ATE will open doors for professional-technical faculty to interface with the peer-reviewed journal process and the value of journals for keeping current with innovations in technical education. It will also provide a vehicle for NSF ATE to demonstrate the value of its work in academia.

MNT-EC designed a unique co-mentoring model for development of ATE proposals, in collaboration with Mentor-Connect. It includes all aspects of proposal development including helping mentees find collaborators and work with their grants/finance departments and senior administrations; design the proposal, and attending meetings with collaborators. It also includes identifying MSIs and coordinating outreach specifically to those 2-year colleges, which is new. This model has already been replicated by other national centers.

The MNT community is an asset for MNT technician education that the center attempted to leverage in innovative ways to increase the impact on students and workforce education in general. While the structure provided a jump start in year one, challenges arose in year two that the PI needs to address. Some suggestions in this regard are found in the recommendations section of this report.

MNT-EC made progress in building capacity for micro nano technology education by growing the number of MNT programs in the U.S.; starting a community of practice to strengthen the programs at nine colleges; starting to develop the Introduction to Nanotechnology course; piloting a system to co-enroll students at colleges from across the country, using distance education; facilitating learning and improved classroom practice for faculty; exploring a new model for more rapidly building support from industry that is automated, using a dynamic database; and working to develop use of VR/AR in MNT classrooms.

SUMMARY CONCLUSIONS AND RECOMMENDATIONS

In year two the center demonstrated a high level of innovation and drive, producing outcomes toward improving the way ATE centers and projects collaborate, and toward improving the micro nano technology workforce development system. In many areas the center exceeded expectations. This included:

- The quality of products and services
- The journal, podcasts, new program start-ups
- Working with the SEMI organization to create a community college-led semiconductor summit where community and technical college faculty and administrators and industry get together and talk about needs from both sides
- Making all center products accessible
- A strong showing with the undergraduate research experience program
- Recruiting students to create a majority-minority cohort not seen in micro nano technology programs in the past
- The center invested in DEI expertise in Dr. Jalil Butler and Dr. Kendrick Davis, and experts in media, curriculum development and undergraduate research.

As is often the case, in year two the center's areas of weakness became more apparent and the data reported underperformance in a few areas. These included:

- Professional development offerings
- Curriculum development
- Leveraging the MNT community
- Veterans initiative

Recommendations to address various areas of challenge have been integrated throughout this report. In addition to those, there are two primary recommendations, both of which are more structural in nature, and impact the center as a whole.

Change the Funding Model and Partnership Structure

Consider moving some of the subawardees to the role of partner. There is a lack of clear boundaries between some centers and MNT-EC in part because there is too much overlap the individuals who are carrying out the activities, the desired outcomes, the activities, and stakeholders. In some cases the centers are working toward the same things through one set of activities. One of the norms for ATE centers and projects is that they work together and help each other out. If these entities were partners rather than subawardees, MNT-EC and the partner would be able to more clearly work out what MNT-EC is doing for them, and what they are doing for MNT-EC. As it stands now, even with contracts in place, some of the subawards are not working. One center is not billing MNT-EC, and saving their subaward money for after they run out of their own funds, which means all of their efforts this year are claimed for their own center. Another center cannot delineate actions they took that are different from what they would have done for their center without MNT-EC. Consequently, MNT-EC is not claiming any of the results they produced this year.

Consider hiring (the PI is already engaging this) some individuals to take on the coordination and administration of major initiatives, instead of the subawardees. Currently all of the major initiatives are led by people who are part-time, many of whom are faculty with heavy workloads. For some, the release time has been sufficient, but for others, it has not worked as well. Ideas include a full-time industry outreach person who works with the MNT-EC Industry Team; the media consultant contract expanded to have more of his time devoted to the center; a dedicated contractor responsible for coordinating the

professional development sessions and also for filling them to capacity. The center may want to ask some of the large centers with longevity about how they are currently organized and the path they took to get there.

Working Groups
Bring all of the activities and coordination of the working groups under MNT-EC. Inform WG leads that MNT^{e}SIG is a partner and encourage their continued participation, but it is not one of their MNT-EC assigned activities. Assign the Center Manager the role of representing MNT-EC at MNT^{e}SIG, reporting on center activities and providing a summary of the needs of the working groups. As already recommended, conduct a monthly meeting with the Working Group Leads and Initiative Leads for them to report out to one another, coordinate activities and provide input on continuous improvement of the center operations.

Change the names of the Working Groups to MNT-EC Teams (e.g. MNT-EC Curriculum Team, MNT-EC Outreach Team, etc.) Using the ideas generated in the Professional Development Working Group, NACK has created a national effort called the Implementing Nano Working Group; MNT^{e}SIG had subgroups, but changed the name to working groups. As might be anticipated, there is a good deal of confusion around the MNT-EC working groups. It is important for MNT-EC to have a clear lane in ATE so the center can clearly claim its results, outcomes and impacts.

Also, consider changing the leads for the working groups. The Curriculum Working Group and the Professional Development Working Group in particular are both under-producing.

Other Recommendations
There are people on the MNT-EC Leadership Team that are unfamiliar, and whose roles are not known by others on the team. It is recommended that the center create a systematic process to welcome any new team members, introducing them, providing some background and describing their role with the center.

Have each working group include in their annual plans specific success metrics. For example, success metrics for the journal might be number of articles submitted, number of articles published, number of proposals that include the Journal, number of centers and disciplines involved, number of journal workshop participants, number of authors and number of reviewers.

Summary
A major strength of the MNT-EC is the expansive vision for the center held by the PI and Center Manager. They keep that vision front and center with the Executive and Center teams, with high expectations for producing results and outcomes. That in its second year, despite the discovery of flaws in the structure, there are eight major initiatives that are producing systemic change in micro nano technology and STEM education, is an extraordinary accomplishment.

Team members are sincere in their support of the center and the center's outcomes and results are strong. The center is well positioned to exceed its goals and objects, and to emerge as an exemplary center for ATE in the years to come.

APPENDIX 1
CENTER ADMINISTRATION

PARTNERS WITH SUBAWARDS		
Institution	**Role**	**Names**
CAST (Contractor not subaward)	Accessibility	Sam Johnston and Louis Perez
Edmonds College	Materials Science and Media	Mel Cossette and TJ McCue
Penn State	Professional Development	Zac Gray and Bob Ehrmann
Portland Community College	Podcasts, J-ATE, Industry Contacts	Peter Kazarinoff
Princeton University	Professional Development	Jim Smith
Purdue University	Dissemination and Distribution	Lynn Zentner, Tanya Faltens and Joe Cytoes
SUNY Poly	Military Transition Training	Abe Michelen and Kate Alcott
University of Minnesota	Curriculum and Safety Seminars	Pete Raynor and Jim Marti
University of New Mexico	Curriculum, Clean Room, Professional Development	Matt Pleil, John Wood and Junifer
University of North Texas	Micro-nano Technology Curriculum, JATE Editorials	Neda Habibi
Cal State Northridge	MNT-CURN Summer Research Internships for Undergraduates	Aziz Boulesbaa
Louisiana Tech	MNT-CURN Summer Research Internships for Undergraduates	Adarsh D. Radadia
Princeton University	MNT-CURN Summer Research Internships for Undergraduates	Jim Smith
University of California, Riverside	MNT-CURN Summer Research Internships for Undergraduates	Yadong Yin
University of Illinois	MNT-CURN Summer Research Internships for Undergraduates	Elif Artemin
University of Indiana	MNT-CURN Summer Research Internships for Undergraduates	James Glazier

CONTRACTORS		WORKING GROUPS	
Abigail Daane	DEI Leadership Retreat Lead	Curriculum Working Group	Lead: Neda Habibi
Ann Beheler	BILT Mentor	Distance Education	Lead: Rick Vaugh
Brandon Rodriguez	K-12 outreach	Industry Working Group	Leads: Cait Cramer, Matt Pleil
Cait Cramer	BILT Lead	Outreach Working Group	Lead: Greg Kepner
Deb Newberry	Curriculum vetting and EMSI data	Professional Development	Leads: Bob Ehrmann, Jim Smith
Janet Pinhorn	MNT-CURN, Podcast and Journal	**INITIATIVES**	
Jill Singer	EvaluateUR, MNT-CURN Data	BILT	Lead: Cait Cramer, Matt Pleil
Jim Smith	Professional Development	JATE	Lead: Peter Kazarinoff, Neda Habibi
Kendrick Davis	MNT-CURN Lead	Military Transition Training	Lead: Kate Alcott
Kenie Moses	MNT-CURN Mentor	MNT-CURN	Lead: Kendrick Davis, Janet Pinhorn
Marco Curelli	Curriculum Subject Matter Expert	Podcast	Lead: Peter Kazarinoff, Janet Pinhorn
Mariel Kolkier	K-12 Outreach	Proposal Mentoring	Lead: Mel Cossette, Greg Kepner
Rick Vaughn	Distance Education Lead	Website	Lead: Billie Copley, TJ McCue
Robert Giasolli	Curriculum Content Creator	Experience STEAM	Lead: Jared Ashcroft~~A~~
TJ McCue	Media Writer and Coordinator	Community of Practice	Lead: Jared Ashcroft
James Hewlett	MNT-CURN Mentor	Curriculum Accessibility	Lead: Luis Perez
Justice Robinson	MNT-CURN Student Mentor	K-12 Outreach	Lead: Mariel Kolkier
Paula Kyria	MNT-CURN Student Mentor	DEI Seminar Series	Lead: Abigail Daane
Shane Nelson	MNT-CURN Mentor		
Sophia Barber	MNT-CURN Student Mentor		

APPENDIX 2
NVC MEMBERS

Members of the National Visiting Committee:

Mr. Robert Sompolski, Dean of STEM and Health Careers [*Chair*]

Mr. Jonathan Beck, Principal Investigator - National Center for Autonomous Technology

Dr. Linnea Fletcher, Principal Investigator - InnovATEBIO

Mr. Nathan Barnhill, Supplier Developer Lead - Pratt & Whitney

Mr. Robin Haines, Director, Process Engineer - Tower Semiconductor

Dr. George Parker, Technical Lead Engineer - The Boeing Company

Ms. Jaclyn Welcher, Quality Engineer II - CIVCO Medical Solutions

Ms. Ruishan Chow, Regional Director Employer Engagement, Palomar College

Dr. Chad Forbes, Professor of Psychology - University of Delaware

Dr. Barry Hester, Dean Business, STEM - Southern University of Shreveport, Louisiana

Ms. Collette Flood, Manager, Workforce Development - Lawrence Berkeley National Lab

*Ms. Shari Liss Executive Director Workforce Development SEMI Foundation

*Dr. Mark Lundstrum: American Semiconductor Academy; Professor Electrical and Computer Engineering – Purdue University

*Added in year two.

Resigned at the end of year two:
Dr. Mary Heiss, Senior Vice President - American Association of Community Colleges

APPENDIX 3
CENTER PARTNERS

Academic Partners	
Edmonds College	SUNY Polytechnic Institute
Portland Community College	The Pennsylvania State University
Princeton University	University of Minnesota
Purdue University	University of New Mexico
Southern University of Shreveport, Louisiana	University of North Texas
Industry Partners	
ASML	Lockheed Martin
Boeing	Malvern Instruments
Bruker Nano Surfaces	MANCEF
Cagent Vascular	Phygen Coatings
CIVCO Medical Solutions	Pratt & Whitney
DiPaola Consulting	Rogue Valley Microdevices
DNP123 Nano	Sandia National Lab
Global Foundries	SEMI
HT Micro	TDK InvenSense
Lawrence Berkeley National Laboratory	TowerJazz
LKD Aerospace	
Affiliates	
American Association of Community Colleges	Normandale Community College
Erie Community College	Omni Nano
Indian Hills Community College	Pasadena Rosebud Academy
Ivy Technical College	Rio Salado College
John Muir High School	Salt Lake Community College
nanoHUB	The Freeman Center
National Nanotechnology Initiative	University of Southern California
ATE Partners	
ATE Central	National Center for Autonomous Technologies
Center for Occupational Research and Development	National Convergence Technology Center
Community College Undergraduate Research Initiative	National Nanotechnology Coordinated Infrastructure
InnovATEBIO	Northeast Advanced Technological Education Center
Materials Science Technology Education	Pathways to Innovation
Mentor-Connect	Project Vision
Micro Nano Technology Education Special Interest Group	Remotely Accessible Instruments in Nanotechnology Network
Nanotechnology Applications and Career Knowledge Network	Support Center for Microsystems Education

APPENDIX 4
TOPICS AND CONCEPTS COVERED IN MNT-EC PROFESSIONAL DEVELOPMENT

TOPICS AND CONCEPTS COVERED IN MNT-EC PROFESSIONAL DEVELOPMENT

Atomic Force Microscopy (AFM) theory and application
Author guidelines and how to access them
Basic Raspbian commands
Data and control charts: Design
Data and control charts: Interpretation
Focused Ion Beam (FIB) theory and application
How MOSFET and CMOS transistors work
How sensors work
How to access the Gr-ResQ database on nano-hub
How to apply MNT health and safety principles.
How to conceive of an idea for your article
How to find and bookmark self-paced lessons
How to read and write signals from and to the Arduino pins
How to use analysis tools to analyze the database
How to use machine learning/deep learning based analysis of SEM images
How to use raman spectrum analysis
How to use templates and author guidelines
How to use the Integrated Development Environment (IDE) to write programs to control devices
How to use the nano-HUB simulations
Installing the PI
Knowledge of the Gr-ResQ platform
Linux Commands Processes
Measurement of airborne and colloidal MNT particles
Occupational hygiene principles applied to MNT
Open access publication
Parts of a submission
Parts of an article
Preventing exposures to MNT particles
Process Variation: Variation Types
Production areas in a wafer fab cleanroom
Programming I/O with Python
Scanning Electron Microscopy (SEM) theory and application
Statistical Process Control (SPC)
The benefits of launching a journal in micro-nano technology education
The benefits of publishing a paper for community college faculty
The components of a microcontroller
The definition of a peer-reviewed journal
The differences between digital and analog systems
The diversity of knowledge that is necessary to work in the MEMS field
The front-end and back-end processes in the manufacturing of chips
The IDLE (Integrated Development and Learning Environment)
The importance of focusing on learning growth and progress in giving feedback
The journal writing and submission process
The many aspects of MEMS
The peer review process
The RPI.GPIO package
The topics covered in the journal
The value to me of having an article published
The variety of MEMS careers

Types of signals
Why accepting late work leads to equitable grading
Why accepting redo's lead to equitable grading
Why using a rubric leads to equitable grading
Why using both formative and summative assessment leads to equitable grading.
X-Ray Diffraction, and Transmission Electron Microscopy (XRD-TEM) theory and application