Implementing the Mechanisms to Lessen the Talent Gap in Advanced Manufacturing

An NSF/ATE Project DUE 1902379

EVALUATION REPORT

Year 1: May 1, 2019 to January 31, 2020

Presented to:

Richard Hendricks, Principal Investigator
Pennsylvania College of Technology
One College Avenue
Williamsport, PA 17701-5799

Prepared by The Allison Group
Seattle, Washington
206-525-7175 tbailey@theallisongroup.com

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This report would not been possible without the collaboration of the Co-Principal Investigator, Bradley Webb. He met with the external evaluator on a regular basis to develop the detailed evaluation plan and fine-tune the evaluation activities. He also compiled the data and information for the evaluation.

PI Hendricks, Co-PI Webb and the project team at Pennsylvania College of Technology produced high quality project documentation that provided an accurate summary of the project's first year of operation.

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List of Tables

List of Acronyms

19MAC	Implementing the Mechanisms to Lessen the Talent Gap in Advanced Manufacturing (Machining Grant 2019)
ATE	Advanced Technological Education
CNC	Computer Numerical Control
DUE	Division of Undergraduate Education
KSAs	Knowledge, skills, abilities
NSF	National Science Foundation
PCT	Pennsylvania College of Technology
PI	Principal Investigator
STEM	Science, Technology, Engineering and Mathematics
TAG	The Allison Group
TBD	To be determined

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EXECUTIVE SUMMARY

The Implementing the Mechanisms to Lessen the Talent Gap in Advanced Manufacturing Project, known as the machining grant 2019 (19MAC), received a three-year award ($591,924.00) from NSF ATE (DUE 1902379) in May 2019, with the grant ending April 30, 2022. Pennsylvania College of Technology (Penn College) in Williamsport, PA is the 19MAC Project fiscal agent.

The 19MAC project seeks to increase the number of qualified workers in advanced manufacturing such that it will combat the growing skills gap between the entry-level workforce and graduates of secondary school and community colleges. During the three years, the project will realign Penn College's manufacturing curriculum to embed more technologically sophisticated skills and increase enrollment in Penn College's CNC certificate program and the two-year AAS degrees in Machine Tool Technology and Automated Manufacturing. The grant will support the increased placement of highly qualified graduates into regional industry positions.

In year one, the grant team under the leadership of Co-PI Bradley Webb has achieved its goals. The team purchased the state-of-the-art equipment, notified all stakeholders, developed input and received initial approval for the curriculum for new courses, certificates, and their foundational programs and initiated assessments for faculty input. Initial challenges in revising the courses and deciding on priorities for students' limited time required extra discussions and extensive considerations. However, a consensus was achieved that the team believes will best support the goals and needs of the students.

The team also launched their website and developed plans for externships for secondary school metal trades teachers and counselors for the summer of 2020.

Business engagement through area manufacturing companies representing both welding and machine tool has been excellent and this augurs well for continued engagement and sustainability.

Co-PI Webb has done an excellent job connecting to multiple opportunities for dissemination through conferences and meetings. He and his team are also to be commended for engaging students early and often in opportunities for leadership and learning. An opportunity for extended training through corporations in Germany led to the development of a supplemental proposal that will provide state of the art training for ten students and two faculty this coming summer. The goal is to contribute to a strengthening of U.S. global competitiveness and to support long-term sustainability of the achievements of the grant.

The project team has opportunities to further strengthen the grant through the development of learning related to broadening the participation of underrepresented populations in advanced manufacturing. This will include ensuring that methods of recruitment to reach students where they are through social media and innovative technology, such as geofencing.

Continuing to collaborate with the evaluator on strategies to assess the program and ensure the full participation of stakeholders in the assessment process should remain a priority for year two.

All indications are that this grant will meet and exceed its goals for the grant.

INTRODUCTION

The Implementing the Mechanisms to Lessen the Talent Gap in Advanced Manufacturing Project, known as the machining grant 2019 (19MAC), received a three-year award ($591,924.00) from NSF ATE (DUE 1902379) in May 2019, with the grant ending April 30, 2022. Pennsylvania College of Technology in Williamsport, PA is the 19MAC Project fiscal agent.

The 19MAC project seeks to increase the number of qualified workers in advanced manufacturing such that it will combat the growing skills gap between the entry-level workforce and graduates of secondary school and community colleges. During the three years, the project will realign Penn College's manufacturing curriculum to embed more technologically sophisticated skills, create a new CNC certificate program and increase enrollment in Penn College's two-year AAS degrees in Machine Tool Technology and Automated Manufacturing. The grant will support the increased placement of highly qualified graduates into regional industry positions.

This report covers year one of the 19MAC project grant, for the period May 1, 2019 to January 31, 2020. The evaluator had multiple phone meetings with Co-PI Webb. The evaluation covers information from those meetings, combined with findings from the data gathered through project documentation. A summary of the approach to evaluation is found in Appendix 1.

Project Goals and Objectives

The project's two stated goals with associated objectives.

Goal 1: Realign Penn College's manufacturing curriculum to embed more technologically sophisticated skills.

Objective 1.1: By the end of Year 1, a one-year CNC certificate program is developed that includes technologically advanced skills needed by industry, as evidenced by updated and revised required student outcomes (RSOs) and course descriptions that align with new equipment and technology.

Objective 1.2: By the end of Year 2, revise the AAS curricula in Machine Tool Technology and Automated Manufacturing to cover technologically advanced skills, as evidenced by updated and revised required student outcomes (RSOs) and course descriptions that align with new equipment and technology.

Objective 1.3: By the end of Year 2, create alignment between the CNC certificate program and the AAS programs in Machine Tool Technology and Automated Manufacturing, as indicated by 6 out of 7 major certificate courses transferring over to the Machine Tool Technology AAS program and 7 out of 7 major courses transferring over to the Automated Manufacturing AAS program.

Objective 1.4: 100% of students in the CNC certificate and AAS programs receive hands-on training on the new CNC multi-axis machining centers and coordinate measuring machine.

Objective 1.4: Penn College has in place a formal process to award credits for completion of an approved apprenticeship program.

Goal 2: Increase enrollment in Penn College's CNC certificate program and the two-year AAS degrees in Machine Tool Technology and Automated Manufacturing, and place graduates into industry positions.

Objective 2.1: 15 students enroll annually in the CNC certificate program and 20 students in the AAS programs by the end of Year 3.

Objective 2.2: 25% of students graduating from the CNC certificate program enter one of the two AAS programs.

Objective 2.3: 90% of students completing the CNC certificate or one of the two AAS programs are placed in a manufacturing position.

Purpose and Design of the External Evaluation

In year one, the Co-PI and evaluator collaborated to develop a detailed evaluation plan. The goal was to produce evaluative data that minimized the amount of overlap between the annual report and the evaluation report. This was accomplished by focusing the evaluation report on outcomes and impacts, and the annual report on activities and results. These efforts resulted in the following evaluative questions.

1. To what degree was the project implemented as planned? What successes were achieved and what challenges were addressed?
2. To what extent did the project activities increase the enrollment of students in technologically advanced CNC programs? Of underrepresented populations in technologically advanced CNC programs?
3. To what extent did the project's work lead to improvement of training and education of the advanced manufacturing technician workforce?

Table 1 below describes the data collection process to gather evidence to address the evaluative questions.

Indicator	Data Sources & Methods	Analysis
Evaluation Question 1. To what degree was the project implemented as planned? What successes were achieved and what challenges were addressed?		
Degree of match between plan and execution of the development and revision of curriculum to align with industry needs	Document review to compare actual process with plan	Comparative analysis of project's methodologies and strategies to develop, revise and align curriculum, revise AAS degree programs, recruit high school students to the advanced manufacturing program and award credit for apprenticeships
Degree of match between plan and execution of revision of AAS degree programs		
Degree of match between plan and execution of recruiting efforts		
Degree of match between plan and execution of the award of credit for apprenticeship		
Feedback from professional development participants on the quality and utility of the workshops	Pre, post and delayed post surveys of faculty participants	Descriptive statistics, including means, top-two box scores and trend analysis; Thematic coding to determine factors that increase or suppress the impact of professional development on classroom practice regarding new technology

Indicator	Data Sources & Methods	Analysis
Evaluation Question 2. To what extent did the project activities increase the enrollment of students in technologically advanced CNC programs? Of underrepresented populations in technologically advanced CNC programs?		
Number of students and percentage from underrepresented populations enrolled in the Machine Tool Technology and Automated Manufacturing AAS degree programs, and the new CNC Certificate	Query of PCT database for current year; for prior years to establish a baseline	Descriptive statistics, both aggregated and disaggregated by demographic characteristics; comparison of data before and after the start of the project
Feedback on the quality and utility of recruiting activities to include teacher externships and Student Symposiums	Pre, post and delayed post surveys of event participants to include evaluation of learning and change in attitude and perception toward manufacturing workplaces and careers	Descriptive statistics, including means, top-two box scores; Thematic coding to determine factors that increase or suppress the impact of the recruiting events on enrollment
Evaluation Question 3. To what extent did the project's work lead to improvement of training and education of the advanced manufacturing technician workforce?		
Opinions of industry advisors on degree of alignment of new curriculum and degree programs with their workforce needs	Surveys and/or interviews with industry advisors; project documentation regarding strength of relationship with industry	Descriptive statistics, including means and top-two box scores; Thematic coding to identify factors that contributed to the degree of alignment reported by industry advisors
Degree of improvement in classroom content of advanced manufacturing programs at PCT	Surveys and/or interviews with faculty who teach the new CNC and AM equipment content	Descriptive statistics, including means, top-two box scores; Thematic coding to determine factors that increase or suppress the impact on classrooms
Student learning and perceptions of preparation for the advanced manufacturing technician workforce	Surveys and/or interviews with faculty regarding their observation of impact of the new curriculum on students; surveys of students regarding self-efficacy and plans regarding advanced manufacturing employment	Descriptive statistics, including means, top-two box scores; Thematic coding to determine factors that increase or suppress the impact on students

Table 1: Overview of Evaluation Plan

In year one, the external evaluator met with the PI and Co-PI to discuss evaluation strategy and establish a regular meeting schedule. In addition, the evaluator and Co-PI met on a monthly basis to update the evaluator on the project activities and establish a detailed data gathering plan and reporting schedule.

Additionally, the external evaluator, in collaboration with Co-PI Webb, developed a survey to obtain feedback on the curriculum development process. The survey was conducted in December-January and four of the ten faculty involved completed it. (One faculty member completed it twice, one month apart.) On most questions, two or three people responded. While the response rate was not as hoped, this early result provides time to review and revise efforts to achieve a stronger response rate for future surveys.

The 19MAC Project documentation was provided with respect to major initiatives, accomplishments and challenges. The results of the project documentation and the meetings with the project team were reviewed, analyzed and then discussed with the Co-PI Webb. The larger themes that emerged are described in this report.

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

Co-PI Webb has done an excellent job in launching the first year of the Penn College 19MAC grant. In addition, Penn College has demonstrated in measurable ways their support and commitment to the grant outcomes. Specifically, the college purchased the two new mills and two new lathes required for the grant. The college also supported the grant through the update of the college website (www.pct.edu/skillsgap) and through the development of courses and programs within the governance processes.

Additionally, the project identified and developed productive professional development opportunities for faculty and students. This will ensure sustainability of the training program long after the grant is completed. Finally, a new one-year certificate program was developed that has a foundation of manual machining methods (mill and lathe) supplemented with CNC techniques and programming principles.

In summary, the program has been managed well in year one, including engaging important institutional support, notifying stakeholders and engaging their support, purchasing and installing new equipment, initiating multiple training opportunities, and developing curricular content to support multiple educational goals.

Activities

The activities in Table 2 below reflect the status of tasks at the completion of the first year of the grant.

	Y1	Y2	Y3	Status
Prepare proposal for certificate	X			Done
Submit proposal and obtain approval	X			Done
Implement CNC certificate		X		On track
Prepare proposal for revised AAS degree programs		X		On track
Submit proposal and obtain approval		X		On track
Implement new AAS degrees		X		On track
Research awarding credit for apprenticeship			X	On track
Implement awarding credit for apprenticeship			X	On track
Select student project for symposium	X	X	X	On track
Outreach to high schools for student participants in symposium day	X	X	X	On track
Implement symposium	X	X		On track
Develop structure for teacher externship program for each year	X	X	X	Done
Outreach to high schools for teacher participants in externship program	X	X	X	Done
Implement externship event	X	X	X	Modified/On track
Review lesson plans/instruction in the high schools		X	X	On track
Disseminate lesson plans		X	X	On track

Table 2: Activity Status Chart

The program activities for year one, including purchasing equipment, developing curriculum, getting approval from both external (advisory board) and internal (college) parties, and gaining training for staff were all met or on track for completion in a timely manner. Infrastructure, such as notifying all parties, discussing developing marketing materials, and convening the advisory board for review of the content were also completed.

The program also recruited and provided training for 10 faculty on Autodesk Fusion 360 parametric design and cam software. This software will be utilized in the new and/or updated manufacturing courses to provide a more diverse training experience. This is an excellent outcome as it may attract a wider diversity of student interest.

Currently, the project team and the college are working collaboratively to prepare for a summer 2020 externship program. They are recruiting 15 technology teachers and/or guidance counselors in Pennsylvania schools from across the state. They have developed a one-week training program that will inform the participants about the varied types of positions available within the manufacturing sector. Penn College currently has dual enrollment programs with area high schools, and this new training will increase opportunities to expand dual enrollment programs in manufacturing, as well as expand opportunities for recruitment. In addition, this activity should help prepare high school instructors to talk about careers in manufacturing with more detail and a better understanding of today's advanced manufacturing sector.

Like all grants, this one also encountered challenges. Specifically, the updates to the current classes for the new CNC certificate caused some "downstream" issues. The original courses also are listed as required within two associate's degrees in machining, the bachelor's degree, and an associate's in metal fabrication. The course modification required revisions to align the changes with the four programs. With only a short time to adjust, the team-identified solutions to ensure no students' course plans were disrupted.

A second challenge arose related to the total number of lecture hours required in several courses. Issues emerged related to student credits (and costs) and total lab hours. The faculty discussed the pros/cons of the options and resolved the matter by prioritizing the importance of the hands-on training. They concluded that successful practice after college required maximizing the amount of time the students had learning/running the equipment.

Finally, the project identified an unexpected opportunity and submitted a supplemental proposal to fund an educational study visit to Germany, a world leader in CNC technology and home of the German Vocational Training System. This unexpected supplemental effort added to the workload of the project team in the new proposal planning and submission. However, it did not negatively affect the current project or its planned activities. In this way, the team exceeded expectations for project management and implementation.

Planning for Sustainability

This project provides many elements that support sustainability. First, the newly purchased equipment will continue to positively impact current student classes and allow students to try new techniques in a safer setting for years to come.

Second, the grant has elevated engagement in the department and empowered the faculty to offer more ideas, help write curriculum, and support new activities. Creating a positive work environment that is

engaged, collaborative, and mutually supportive will provide benefits to the department and the college long after the grant ends.

The new and revised courses have been added to the official curriculum, ensuring the concepts are sustained in the educational offerings.

Perhaps most importantly, Penn College is currently recruiting for the one-week (40 hour) teacher externship event for summer 2020. Pennsylvania teachers who participate will earn needed continuing education credits. They will also benefit from connections with industry, learn about manufacturing processes, gain hands-on experience with using machining equipment, be provided with sample lesson plans, and be required to develop a project that links the content learned on campus to their lesson plans at their home school. The teachers will be compensated for their week on campus with a stipend and continuing education hours (required for teachers in Pennsylvania), and, as an additional incentive, after providing evidence of implementing their project, they will be awarded an additional stipend. Providing this training and incentives for both continuing education and stipends ensures educators' engagement and program completion.

The externship program in particular supports sustainability by expanding the recruitment pipeline across the state, reaching more educators, counselors, and parents across multiple communities, and addressing traditionally underrepresented populations. The project team reports that the high schools have been very excited about their ideas/progress. Like many machining programs, student recruitment has been a challenge. The externship program will provide both metal trades teachers and counselors with the ability to talk knowledgeably about the "trades" This is important for closing the knowledge gap.

One caveat for Co-PI Webb and the other faculty to consider as they implement the externship program is to provide content related to gender and racial access and equity so as to open the opportunities in the trades to as many students as possible. The summer program offers a unique opportunity to overcome some of the traditional gender or other biases that remain in our culture.

Dissemination

The grant team has done an excellent job disseminating information about this grant and the grant outcomes. The following communities have benefited from 18 unique activities.

- K-12 teachers and counselors - 68
- Two-year faculty - 32
- Students - 18
- Industry - 29
- Community - 2

Multiple faculty participated in presenting or attending meetings to both learn from others and share their work in an effort to ensure program success.

In addition, the grant launched a website related to the project to disseminate new developments to the community. The impact of the website has elements that will help understand the reach of the effort. In addition, the project has not yet made efforts related to social media. Given the well-established impact of social media in the U.S. culture today, the team would do well to build this into their dissemination plan for year two.

Industry Collaboration

Businesses representing welding and machining companies participated in a manufacturing advisory meeting. Members from Keystone Friction Hinge (Michael Brown and Alex Witter) and PMF Industries (Ken Healy) attended along with multiple guest companies, represented here:

- First Quality Products – (Rick Bloom)
- Acero Precision (Jason Wolf)
- Victaulic (Jesse Dorn)
- Jersey Shore Area School District (Brent Wheeland)
- Gosinger Inc. (Bill Wilson)
- Lycoming Engines (Tyler McCoy)
- Trak Machine Tools (Michael McGarry)

During the meeting, the NSF grant was announced along with the deliverables of the grant and the supplement. The advisory committee was provided an opportunity to understand the planned changes, ask questions, and provide input.

Supplemental Proposal

As mentioned above, the project identified an unexpected opportunity and submitted a supplemental proposal to fund an educational study visit to Germany. On the proposed 16-day trip, 10 students and 2 faculty chaperones would receive training at the Eckert International Vocational School, a leader in German Vocational Training, and meet with numerous companies that are on the cutting edge of CNC and automation technology, such as Voith, Siemens, and BMW. The trip will allow the faculty to experience the dual system in action and give students exposure to a tailored German Industrial Training designed specifically for the group. The faculty participants will also participate in a workshop on the dual vocational education system and have access to Eckert faculty and the program administrators for in depth discussions. Eckert agreed to manage and lead the training, provide educational materials, and arrange some company visits.

Three main training objectives for the student centered programming are:

1. Machine construction with Siemens Solid Edge. Solid Edge is a parametric design, simulation, and computer-aided design/computer-aided manufacturing (CADCAM) portfolio of software tools used in the product development process. Solid Edge training will introduce the students to the main concepts of direct modeling with the flexibility and control of parametric design.
2. CNC Machining. SINUMERIK Operate Shopmill and Shopturn. Also, a Siemens-based parametric design, simulation, and CADCAM software system, the SINUMERIK Operate software training will provide students with basic knowledge of the user interface, powerful functions, and tips and practical knowledge for milling, turning, and working with multitasking machines.
3. Robotic basics. Students will receive a basic overview of the setup, programming, and implementation of robotic systems used in the manufacturing industry.

Following the training period, the faculty and students will visit several leading CNC technology companies' showrooms to learn more about their technologies and gain exposure to the training units they use to teach these skills. Upon their return, the faculty will develop and integrate new strategies for implementing the content they learned with all their students, as well as ideas for hands-on application of the theory. The trip will support ongoing program development and expand improvements currently in development (or recently developed) through the originally funded NSF ATE Proposal. The enhanced

hands-on teaching will increase the relevance of the CNC certificate offerings, as well as the AAS programs, by strengthening alignment of curriculum and pedagogy to meet industry standards and innovative developments in manufacturing.

Collaboration with Colleges and Other ATE Centers and Projects

In planning for the externship program in summer 2020, inviting engagement from Pennsylvania State University (PSU) is under consideration. This was recommended by the advisory board. Additional collaborations are likely to develop in future years as the grant team continues to attend and connect to other NSF grant recipients (through ATE meetings) and manufacturing programs in the state and across the U.S.

QUESTION 2: To what extent did the project activities increase the enrollment of students in technologically advanced CNC programs? Of underrepresented populations in technologically advanced CNC programs?

The new curriculum is on track to be implemented in the Fall 2020. The data regarding the enrollment and demographics of students will be collected from the Penn College Institutional Research Office and will be reported in year two. As noted above, building in elements for broadening the participation of underrepresented students in the externship summer program will an important aspect of achieving this goal.

QUESTION 3: To what extent did the project's work lead to improvement of training and education of the advanced manufacturing technician workforce?

Development of New Curriculum

The development of curriculum was a primary goal in year one. To that end, the team successfully achieved the following:

- Developed a new one-year certificate program that has a foundation of manual machining methods (mill and lathe) and supplements that with CNC techniques and programming principles
- Revised six (6) existing courses to embed CNC techniques.
- Added a new course in CAD/CAM foundations.

The new coursework provided the college with the needed instructional infrastructure to meet today's manufacturing workforce needs. The purchase of the two new mills and two new lathes with the CNC technologies coupled with this new coursework ensures the college can train students on the latest technologies and prepare them for the globally competitive manufacturing workforce. The advisory committee that reviewed the content and program were pleased with the outcomes. Currently, the curriculum is progressing through the formal educational channels for approval. The process is expected to be complete in March 2020.

Consistent with the goal of continuous improvement, a survey was developed and sent to the faculty for their input. Five responses were recorded suggesting five respondents. However, two of the five faculty were actually the same person responding one month apart.

All responses were from the Fall of 2019. Of the 13 questions, most of the questions had only two or three responses and it appears two of the responses were typically from the same person. This is unclear.

Before a survey is again sent out, it will be helpful to determine whether the respondents believed they could not answer the question (for whatever reason) or did not feel the question was relevant to him/her/them.

Given the limited responses, reporting on the survey results has limited value. Nevertheless, the information provided by some of the questions may be instructive, and are summarized in Table 3 below.

Faculty Questionnaire: Curriculum Development Process	
Question	**Response**
Q. 4. Did you follow a planned development process? If so, what?	(1) No, (2) Not really, (3) Regular department meetings using general guidelines for creating a one-year certificate, along with necessary technical training outcomes as goals.
Q. 5. Did you have a more ad hoc process? If so, what sort of issues, ideas or incidents caused you to move forward in the process?	(1) No, (2) I believe we did more ad hoc. We consulted with various industry partners as well as advisory board members. We also visited some of our competing colleges and universities, tool and machine shows, and training sessions to decide on course content, equipment and technology to acquire.
Q. 6. What did you start with? Were there existing materials? Was there an existing course or model to work with? Were there prior ideas of what was needed?	(1) Existing programs, courses, equipment and technology was used to build upon for improvements. The crucial part of our new CNC certificate program design was asking industry what our students need to be prepared for the everyday demands of a CNC setup, operator and programmer. (2) Department already had 2-year certificate in machining. Credit limitations were in view as current courses were evaluated for revision and new courses needed to incorporate CNC technology were added. (3) existing models.

Table 3: Faculty Questionnaire Selected Responses

Impact on students

The team is to be commended for their inclusion of students in their activities. In year one, students participated in the advisory board meetings (3 students at the meeting). Empowering students in these kinds of leadership activities will grow students' leadership capabilities, as well as support their workplace skills.

The curriculum will be implemented in the Fall of 2020 and feedback from students will be gathered regarding the impact on their learning and attitudes and perceptions of advanced manufacturing careers.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The major finding from this evaluation report is that the 19MAC Project is making excellent progress toward meeting its goals. The team has built the infrastructure of people and products needed to complete the project's goals and timelines, and has the resources in place to meet its objectives over the course of the grant.

In year one, the project completed the following:

- The purchase of equipment.
- Extensive dissemination efforts were developed and deployed.
- Curriculum needs were met to align with the new, more advanced equipment and meet the needs of a growing diversity of student interests.
- An extensive business community is supportive and engaged to achieve project goals.
- New courses, certificates, and programs that are foundational to the manufacturing education pipeline are moving through the college's academic process for formal approval.
- Initial assessment tools, processes and people are in place to evaluate participant (teacher, faculty and student) understanding and learning, and measure program value, utility and capacity to impact the manufacturing workforce in year two.
- Recruitment tools for the teacher and counselor summer externship are developed and recruitment is getting started.
- A supplemental proposal for funding was awarded for two faculty and ten students to travel to Germany and learn about cutting edge advanced manufacturing training. These activities will help keep the U.S. globally competitive and PA locally able to provide a high quality workforce for years to come.
- The engagement of other colleges and ATE Centers is planned and likely to be successful given the level of dissemination efforts in year one.

The 19MAC team is to be commended for its flexibility, innovation, and focus in launching the work of this grant and for its commitment to developing state of the art manufacturing education in the region. In the time covered by this reporting period, the project has accomplished the goals planned for year one and is on course for exceeding its goals and objectives planned for the grant overall.

Recommendations

It is recommended that the PI work with the external evaluator on the following:

1. Consider identifying an individual or organization that can provide expertise related specifically to increasing the participation of underrepresented students in advanced manufacturing.
2. Continue to develop marketing materials and strategies (social media) that can both reach and speak to a wide diversity of students who may benefit from enrollment in the new pathway programs. Consider not just the potential income for students, but also the prestige of the jobs and the relevancy to serving the world – key issues for Generation Z students. Many colleges are using "geofencing" as a new method for reaching students who are most likely to benefit from their programs.
3. Consider opportunities for further developing networks with other ATE Centers and projects to identify and support needed knowledge and resources.
4. Continue the excellent work with the evaluator to expand and develop data gathering methods and instruments to improve participant feedback to better inform outcomes.

APPENDIX 1

APPROACH TO EVALUATION

Approach to Evaluation

Theoretical Foundation

The evaluation is primarily based on adaption of the Context-Input-Process-Product evaluation model developed by the Evaluation Center at Western Michigan University, under the direction of Arlen Gullickson, PhD and Daniel Stufflebeam PhD[1]. The year's activities were evaluated following Gullickson'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. The following methods were used to develop the data necessary to cover the topics in the evaluation plan:

- Interviews with Principal Investigator, Co-Principal Investigators, project staff, partners and faculty.
- Determination of impacts and influences on technician level education.
- Analysis of documents.
- Analysis of applicable survey and other data gathered to date.

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' IRB (Institutional Review Board).

The evaluation covers findings and recommendations, discussions with PI and staff combined with findings of the data gathered through surveys, interviews and data analysis.

[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.