

Discerning Advanced Manufacturing Education Pathways: Insights from Rural Northwest Florida's Program Origin Stories

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Abstract

School-to-career pathways not only represent a student's journey, but they also represent the educational program context; to understand the pathway, one must understand the geographic, political, and social conditions that led to the program's creation. To determine the kinds of pathways advanced manufacturing (AM) programs in rural Northwest Florida community and state colleges enabled for their students, we interviewed faculty and administrators about their AM programs' historical emergence. In this paper, we present five detailed AM program "origin stories," using a multiple case study methodology. These origin stories allowed us to explore how rural AM postsecondary programs have evolved in organizational structure, curriculum content, employer relations, and student pathways facilitation. We gathered data to discern 1) commonalities and unique features in AM programs' initiation impetus; 2) current AM program, faculty, and student profiles; and 3) significant AM program challenges and priorities in rural settings, such as institutional commitment to long-term economic health. In our findings, we highlight how active participation in diverse community and industry collaborations serves to establish and grow AM educational pathways tailored explicitly for the immediate community. For example, participants share innovative partnership programming and certificate development that enabled seminal two-year engineering technology and engineering technician education opportunities. We also identified that the ability of rural programs to offer instruction in advanced physical spaces requires an ongoing commitment to appropriate resources, support that is variously obtained from the institution, local employers, or some combination of stakeholders. Through our methodology and findings, we aim to contribute to a holistic understanding of how to study school-to-career pathways to inform how rural AM programs can advance to achieve competitive growth.

Introduction

School-to-career pathways not only represent a students' journey, but they also represent the educational program context. One must understand the geographic, political, and social conditions that led to the program's creation to understand the pathway. These origin stories allowed us to explore how rural advanced manufacturing (AM) postsecondary programs have evolved in organizational structure, curriculum content, employer relations, and student pathways facilitation. To understand how AM program leaders view their AM programs in their unique rural contexts, we gathered foundational histories, or "origin stories," of these programs to answer the following research questions:

- (RQ1) What are the commonalities and unique features of regional AM programs' origins?
- (RQ2) How do the curriculum, faculty, and students compare among the programs?
- (RQ3) How do the challenges and priorities that AM programs experience in rural settings compare and contrast?

Literature Review

While the literature documents the history of community and technical institution, researchers have not studied the origins and historical context of AM programs within these institutions as widely.

Community Colleges as Local Educational and Economic Anchors.

State, community, and technical college systems are the primary providers of AM and technical engineering programs. Community colleges, as junior colleges, emerged in the early 20th century to prepare students for delayed entry into a 4-year program [1]. Institutional missions greatly expanded to provide occupational education, community services, and workforce development and continue to evolve. The introduction of AM and technical education is just one example of the responsiveness of the community college system to a myriad of labor, community, and student needs; however, funding, public perception, relative emphasis, purposes, and value have persisted as community college challenges [2].

Community college mission statements reveal a number of the challenges community college and technical leaders faced such as globalization, inequity, technological revolution, and diminishing public investment as they worked to establish a collective sense of purpose through using mission statements in the second half of the twentieth century [3]. Community colleges have historically pursued multiple, sometimes conflicting, missions shaped in part by unique geographic and community factors [4]. Each community college faces unique location-based challenges and opportunities, but community college leaders have been successful in strengthening the immediate labor market to facilitate and support local economic development [5]. Community colleges are uniquely positioned to be responsive to the unique needs of their region by engaging not only economic development, but also in improving students' career prospects and community sustainability [5].

Rural Community Colleges and the Manufacturing Workforce.

Geographic factors are particularly significant to the rural manufacturing industries. For example, during the 1970s, traditional factory jobs in rural communities increased approximately three times faster than those factory jobs in urban settings because of lower operation costs in rural areas throughout the United States [6]. Community, state, and technical colleges historically support rural manufacturing by providing programs to develop skilled workers, distributing innovation and technology, and delivering business services and information [7]. AM accounts for a quarter of rural Northwest Florida's total manufacturing jobs and anticipated productivity growth rates depend on more highly trained workers [8]. For these reasons, Northwest Florida's rural state and community college leaders are well positioned to directly support the local economy by providing advanced skills and technical training through their AM programs [9].

Two Year Programs and Advanced Manufacturing Curricula.

While the curriculum of each AM program develops within its unique geographic, leadership, and institutional context, the U.S. Department of Labor's Advanced Manufacturing Competency

Model is a critical resource used in all AM program curriculum [10]. Stakeholders use the Advanced Manufacturing Competency Model to guide and develop competency-based curricula that align with the skillsets and knowledge expected by industry employers [11]. Overall, the Advanced Manufacturing Competency Model used in curriculum development is further demonstrated to be compatible with the competencies taught in AM programs, finding that student’s personal effectiveness were perceived of greater importance than the coverage of these skills in their AM programs [12]. Many academic institutions also use the Society of Manufacturing Engineers (SME) Four Pillars of Manufacturing Knowledge model to complement the Advanced Manufacturing Competency Model in AM curriculum development. The SME Four Pillars model details fundamental knowledge for manufacturing to map to curriculum, but also program accreditation [12], [13]. At the recent Florida Engineering Technology Forum, state-level education leaders remarked that the Florida Department of Education’s state and community college AM curriculum framework, which is informed by the Advanced Manufacturing Competency Model and Four Pillars of Manufacturing Knowledge, was the most uniformly implemented curriculum of all career and technical education (CTE) programs.

Methods

In this study, we used multiple case study methodology [14], [15] to determine the kinds of pathways AM programs in rural Northwest Florida community and state colleges enabled for their students. We conducted a detailed AM program origin story analysis of five AM program cases.

Participants. Figure 1 shows an outline of this case study program design and details.

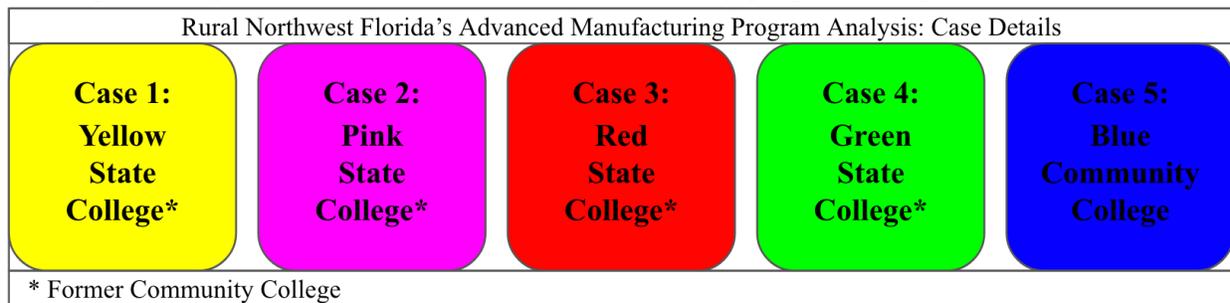


Figure 1. AM programs reflected in the study’s cases

The cases illustrated in Figure 1 reflect both one community college and four state college AM programs located within Northwest Florida. The historical and political context is important to briefly review when considering the institutional profiles of community and state colleges in the state of Florida. The four state colleges each historically originated as a community college before becoming a state college. The 2008 Florida Senate Bill No. 1716 provided Florida’s 28 community colleges with the choice to participate in a pilot to transition to state colleges as the bill replaced the Florida Community College System with the Florida College System [16]. As state colleges, these institutions would be allowed to confer a limited number of Bachelor’s degrees; in all, 21 of 28 colleges were approved for at least one baccalaureate degree by the end of 2011 [17]. While these case study programs are housed within 4-year institutions, the AM programs offer students Associate of Science (A.S.) degrees and certificate programs. According

to leaders from the colleges in this study, students graduating from these AM programs might wish to pursue bachelor programs at their college or at another institution after completing the AM program.

Data Collection and Analysis

Our data were composed of interviews and secondary data analysis. For our interviews, we identified and interviewed at least one faculty member or administrator from each of the programs illustrated in Figure 1. Early collaboration with partners at the case sites proved instrumental for us to identify additional faculty and administrator for participation in this study. We used a semi-structured interview protocol to learn about their AM programs' emergence. We provide the interview protocol in the Appendix. We interviewed seven participants from the five case programs. We transcribed each interview for qualitative thematic analysis as part of the multiple case study methodology [14], [15], [18].

To supplement our interview data and create a fuller picture of each college and program, we gathered secondary data in the form of curriculum details and publicly available institutional information from AM program websites and the National Center for Education Statistics (NCES) (<https://nces.ed.gov/globallocator/>). This secondary data enabled us to confirm and supplement historical origin details provided in the origin interviews with each program's current program and curriculum structure.

We used NVivo software to perform an open coding to discover emerging themes to map to the interview text. We comparatively analyzed to build on general themes that fit all the individual origin stories [19].

We have excluded identifiable information to maintain confidentiality in reporting the findings.

Validity and Reliability.

To confirm, extend, and provide additional context for our themes, in January 2019, we gathered insights from three AM education leaders who reflect a broad perspective of AM programs statewide and nationally. These experts confirmed our resulting themes and identified additional themes for us to investigate.

Findings

Case 1: Yellow State College

According to the U.S. Department of Education's Common Core of Data (CCD) database, Yellow College is a four-year, primarily Associate's degree granting, public institution located in a distant town campus setting. Yellow College has approximately 2092 students, 43 full time faculty and 141 part time instructors. The AM program was founded within the 2014-2016 timeframe and currently enrolls 26 students. Yellow College offers AM curricula such as engineering technology A.S. and a welding certificate program.

Yellow College's AM program developed in response to local industry's need for experienced employees. An instructor from Yellow College explained that a local industry leader worked closely with them to develop the program to provide students with the required advanced skills. This collaboration resulted from the local industry's inability to provide inhouse training quickly enough.

Yellow College faculty and administrators worked closely with local industry leaders to develop a curriculum informed by the state level AM curriculum framework [19] and based on immediate industry needs. Yellow College's dean shared that the college had also used Florida Advanced Technological Education Center (FLATE) recommendations to develop their program. In addition to relying on the frameworks, Yellow College engage collaborative assessments to keep their AM program curricula current. The Yellow College dean explained that faculty and administrators frequently collaborated with local manufacturers and advisory committees to identify needed curriculum updates. The dean expressed that by listening to local industry partners and the advisory committee, program leaders gained insight into current trends and needs in their region. This process enables the responsiveness of their program to local industry, community, and regional evolution.

Yellow College reported employing a small number of small AM faculty. The Yellow College dean shared that employing only one full-time credentialed faculty member was a serious challenge faced by the AM program leaders. The dean from Yellow College reported the challenge of identifying appropriately credentialed prospective faculty to meet the pressing need to better distribute teaching assignments and the instructional demand of growing enrollment. The Yellow College dean shared that as a result of the limited number of faculty, their one full-time faculty member often taught up to six courses a semester. This dean pointed out a need to equitably delegate teaching responsibilities to multiple faculty members to grow the AM program.

The dean described an additional challenge of meeting local accreditation standards that require transferable courses be taught by a faculty member with a Master's degree and 18 hours of disciplinary specialization. The dean further shared that although they were able to find faculty who could effectively teach in their program, they needed to create a better system to enable these people to meet specific accreditation standards.

Yellow College's primary technique for student recruitment was through grassroots efforts. The dean from this college explained that faculty visited local K-12 schools and provided virtual AM program promotion sessions, including a video featured on their website. In addition to word of mouth, the dean further explained this high touch method of recruitment involved collaborating and sharing their AM marketing material with local government officials, workforce development staff, and regional AM industry organizations.

The dean ranked consolidation of teaching sites, currently scattered across campus, as a strong need. A focused site, the dean contended, would strengthen the program's identity and enable students to build stronger relationships with each other and faculty. The dean from Yellow College added their connection to industry through sponsorship and programming was an ongoing priority.

Case 2: Pink State College

Pink College is a four-year, primarily Associate's granting, public institution located in a small city campus setting. According to the NCES, Pink College has 5,379 students, with 141 full time and 188 part time faculty. Pink College's AM program was founded in 2012 and offers AM curricula such as the engineering technology (ET) A.S. program.

Pink College developed their AM program with a regional economic development grant. The Pink College dean explained that the funding was linked to regional workforce demand for greater STEM technical skills. This funding opportunity resulted in an AM facility which served as the basis for the AM program; dean added that Pink College did not have advanced technology STEM-based programs prior to the AM facility's construction.

Pink College has participated in regional collaboration to promote their AM program and recruit students. A staff member from Pink College shared that the AM program leaders were active in the local community and that this participation helped to raise awareness of the AM program and attract students. For example, leaders from Pink College's AM program collaborated with a local military base and the local industry leaders to recruit students from active, reserve, and veteran military members. The staff member explained that Pink College had also initiated a successful navigator program with regional high schools. This navigator program embedded staff from Pink College in the local high schools to assist with student counseling and identifying academic opportunities guidance. Pink College's dean reported the military and school collaborations resulted in curriculum suggestions for the new AM program, so as autonomous vehicle manufacturing and maintenance skills.

Pink College's AM program relied on existing AM frameworks [20] to develop their initial AM curriculum. Pink College collaborated with regional industry leaders to further tailor the framework to meet anticipated technical skills in the workforce. The dean from Pink College explained that, in addition to this collaboration, leaders from the AM program used FLATE resources to design an AM curriculum adaptable to the continuous change for specific technical skill demands. The Pink College dean reported that AM grant opportunities, such as regional initiatives, helped scope their AM program development through collaboration with additional regional colleges to identify the unmet regional training demands.

Pink College's dean that maintaining adequate faculty was top challenge. Pink College faculty had only one full-time credentialed AM faculty member. Pink College's AM program leaders cited faculty credentialing as a key challenge to hiring additional qualified instructors. Another key challenge was increasing student enrollment. An Pink College instructor reported that approximately 65 students were in their ET program and that the majority of their students worked full-time and pursued the AM degree part-time. Pink College AM leaders identified increasing the number of full-time students as a need, especially to increase the number of women and minorities in the AM program.

The Pink College AM dean reported that updating their curriculum as a persistent priority because it was challenging to, "keep up with offering a curriculum in the timeframe that it is

needed to meet the needs of industry.” A faculty member acknowledged that the lengthy process of working with accreditation bodies was a challenge that slowed AM curriculum responsiveness. A Pink College faculty member highlighted the related challenge of continuing current faculty education to meet the instructional expectations of an evolving curricula. The Pink College faculty member explained, “We might have been experts at one time, but if we don’t stay up on top of things, we’re going to fall behind too.” Pink College’s dean identified the overarching challenge and priority of securing continued funding to sustain and grow the AM program in the absence of ongoing grant funds.

Case 3: Red State College

Red College is a 4-year, primarily Associate’s granting, public institution located in a fringe rural campus setting. The NCES lists 2,092 students with 43 full time and 141 part time faculty. Red College’s AM program began with manufacturing technology and evolved to AM today; it currently enrolls 61 students. Red College offers curricula such as the ET A.S. program with curriculum in digital manufacturing and electronics. The program includes curriculum in drafting and design program in an architecture design and construction technology. Red College AM programs include a transferable pre-architecture degree geared to students who intend to become architects. Red College’s CTE programs also include graphic technology, computer engineering technology, networking technology, and welding. Red College’s includes AM among its technology programs with engineering applications.

Red College’s department chair reported that their program origin can be traced back as early as 1984 with manufacturing technology programs. The department chair explained that their existing manufacturing technology program could not encompass the growing AM program’s curricula, so they renamed the program to reflect the advanced manufacturing content. Red College’s administration supported their AM programming in response to a decline in student enrollment and rapidly changing leadership priorities. While the nature of the cause and effect relationship between leadership change and enrollment was not explicitly clear, Red College’s AM program leaders cited a connection. The AM department chair explained, “[The change to AM] was driven by the administration here at the College.”

Red College’s AM program leadership reported relying on existing state level AM frameworks in developing their curriculum; they also used material from National Center for Construction Education and Research (NCCER). Red College had a few full-time AM faculty and the program leaders cited faculty credentialing as top challenge to hiring more faculty. The AM program chair shared, “We have all sorts of people locally [who] can meet our needs on adjunct basis, but the full-time [people] are hard to come by, and that's where we struggle.”

In addition to relying on frameworks to keep their AM curriculum updated, the Red College department chair explained that a diverse advisory board, meeting formally at least twice a year, contributed to ongoing curriculum assessment and updates. The Red College AM advisory board changes over time but the program leaders invite technician and manager membership from local industry as well as representatives from local school systems. Red College AM leadership added that the AM program is evaluated every three years.

Leadership from Red College's AM program reported using standard institutional student recruitment efforts to attract AM students. In addition, Red State College's AM program leaders reported collaborating with local high school curricula to raise awareness of their programs by sharing resources, such as inviting a local high school to use Red College's computer numerical control (CNC) machines as part of a planned memorandum of understanding (MoU) between the schools and the College.

Red College's leadership reported that their top priorities were also their top challenges. For example, the department chair stated AM program growth to meet industry needs was a top priority and a top challenge. The department chair also cited funding for facilities, resources, and faculty, as a priority and a challenge to securing the growth of their AM program.

Case 4: Green State College

Green College is a four-year, primary Associate's granting public institution located in a small city campus setting. The NCES lists student population as 9,655, with 180 full time and 334 part time faculty. Green College's AM program origins are as early as 1992, with a traditional manufacturing technology program. In 2000, the manufacturing technology program evolved to include AM programming, and currently enrolls 78 students. According to a faculty member from Green College, in 2000, most of the college's existing technology faculty retired. This staffing issue presented Green College with the opportunity to transition an existing technology program's curriculum from manufacturing technology to advanced manufacturing.

A Green College faculty member explained leaders hired faculty with AM experience and partnered with local industry to secure the necessary equipment to provide students with expected hands-on AM industry skills. A direct need for advanced technical engineering in the local community and industry drove Green College's AM program development. A Green College faculty member explained this program framing needed to be quick for students to complete the program in time to meet pressing local industry's hiring needs. During this time, program leaders from Green College collaborated with the Florida Department of Education to establish specific engineering technology frameworks. In addition, at this time the Green College leaders also aligned their AM curriculum with the FLATE curriculum recommendations.

Green College has a small AM faculty with two full-time faculty and several adjunct instructors. A Green College faculty member identified a small faculty as a challenge to growing the AM program. In addition to instructors, the Green College AM advisory committee served a critical role in curriculum development. A Green College faculty member explained, "With our advisory committee, we started early in the program by combining the advisory committee with an open house." This open house, which is currently still offered, allows members of the advisory committee to observe faculty and students during class. This observation provides the committee with direct experience of the skills and knowledge provided in the current curriculum. AM Green college faculty explained that feedback from the advisory committee is critical in updating their curricula to meet industry expectations. A Green College faculty member reported that their AM program relied on standard metric-based institutional review guidelines to evaluate the AM program.

The Green College AM program provides local manufacturers with continuing education to learn the skills necessary to operate new equipment, gain additional advanced technology skills, and learn to use new software. Green College faculty reported that the average age of their AM students was around 30 and that the majority of their students pursue the AM program part-time as they work full-time jobs. An AM Green College faculty member explained that the program consists of approximately 15 students consistently in recent years. In addition, Green College faculty also noted the AM program enrolls a number of students with autism who were very successful.

Green College faculty reported supporting current equipment and securing updated equipment, AM program growth, and student success as both top priorities and challenges. Green College faculty report securing and maintaining the AM equipment, such as a machining, as a priority to successfully train students in evolving AM skill sets. AM Green College faculty further identified AM program growth as critical to continue to meet the expectations of industry driven skills and knowledge. A Green College AM faculty member expressed that students often entered the AM program lacking basic academic skills and that this deficit was a challenge to address while also providing advanced technical skills.

Case 5: Blue Community College

Blue College is a four-year, primarily Associate's granting public institution in a midsize city campus setting. According to the NCES, its student population is 11,782 with 173 full time and 551 part time faculty. Blue College's established the AM program in approximately 2006. The Blue College AM program offers the Associate's of Science (AS) degree in ET and awards postsecondary adult vocational (PSAV) certificates. Blue College's faculty is small, with one full time and one part time faculty.

Blue College's AM program director traced the program's origin to an early technology program that evolved over time into the AM program. The director detailed the AM program's journey started as an electronics technology program. New industry entered the local community, and those employers required advanced workforce skillsets. A director from Blue College explained that their previous technology program did not meet the new industry's needs. In response, Blue College's CTE leaders initiated AM programs to produce the needed skilled workers. Blue College's AM program director explained that a college, industry, and community group effort to 1) build a facility that would house AM equipment; and 2) create educational programs around to make use of the resources in that facility.

Blue College leaders relied on the FLATE framework to inform the new AM program's curriculum. NSF grant funding enabled Blue College leaders to hire one full-time AM faculty member and develop a dual enrollment program with a local high school system. Leaders from the Blue College AM program experienced a challenge in identifying a qualified full-time faculty member because hiring credentialed AM faculty as a statewide AM challenge.

According to a director from the AM program, Blue College was unique because approximately 40% of their students attend from out of immediate area, rather than a smaller percentage of non-local students reported at the other participating colleges. This percentage of out-of-area students

presented a challenge for leaders of the AM program who aligned the AM curricula with local industry. Blue College's AM program leaders explained the challenge of communicating the opportunities the AM program can provide to distance and university-bound students. Blue College participants cited communicating AM opportunities as a serious challenge to recruiting students to the program.

The Blue College AM program is evaluated annually. Blue College's director explained that, in addition to advisory board feedback and student evaluations, the review is primarily metric and performance-based. When asked what Blue College's top priorities were, the director immediately identified increasing program enrollment and total program completion. Blue College's director also pointed to funding, locating faculty and instructors, and employer engagement as both top priorities and challenges.

Discussion

Commonalities and Unique Features

Historically, rural community, state, and technical colleges have fulfilled a mission to support rural manufacturing primarily through providing the programs to develop skilled workers [7]; this historical mission is supported in this study of rural Northwest Florida's AM program origins. While the unique industry and community environment differed across the programs, each rural Northwest Florida AM program in this study reported supporting local industry through working to align AM program curricula with the needs of local industry. For example, a Yellow College dean spoke about keeping their AM curricula current by actively listening to industry partners. A dean from Pink College identified the importance of understanding the needs of local industry. A faculty member from Red College shared that the AM program ensured that their program advisory committee includes members from industry. A faculty member from Green College's explained the importance of AM leaders to seek out industry collaboration. A director from Blue College explained the opportunities they provide to involve local industry in their AM curricula development. This active, intentional, and ongoing communication with local industry is a commonality of the rural Northwest Florida AM programs in this study to support rural manufacturing by ensuring the curricula of AM programs supports developing skilled workers.

AM leaders reported unique details in the precise origins of their programs. Pink College was the only program founded with a regional grant to increase STEM based technical skills in response to community and industry demand. The dean from Yellow College cited the demand from local industry leaders for specific technical skills led to the development their AM program. A faculty member from Green College detailed the historical transition of their previous manufacturing technology to their current AM program. The Green College faculty member explained that the programs transitioned mapped to meeting the need of technical skills of new industry leaders in the regions. The director from Red College explained that the AM program administration collaborated with local industry to develop their AM curriculum. The Blue College director reported a transition from a previous electronics technology program to their current AM program. The director from Blue College explained this transition was driven by changes in local industry and the required technical skills expected in the workforce.

While the AM leaders' driving factors were unique to each case, one commonality is the effect that local industry skill demand has on AM program development, even if imparting those skills is at odds with activities that support personal effectiveness and general academic skills. This theme is somewhat at odds with the researchers who reported that AM students perceived personal effectiveness competencies as of greater importance than the skills gained through their AM program [12]. Our research finding supports future research into the role of personal effectiveness skillsets in AM program curricula.

AM Curriculum, Faculty, and Students

Leaders of two-year programs and advanced manufacturing programs rely on frameworks to operationalize their curricula. For example, the literature review revealed that the U.S. Department of Labor's Advanced Manufacturing Competency Model is a critical resource used in AM program curriculum [18]. AM Stakeholders use the Advanced Manufacturing Competency Model to guide and develop competency-based curricula that align with the skillsets and knowledge expected by industry employers [19]. Additionally, many academic institutions use the Society of Manufacturing Engineers (SME) Four Pillars of Manufacturing Knowledge model to complement the Advanced Manufacturing Competency Model in AM curriculum development. The SME Four Pillars model details fundamental knowledge for manufacturing to map to curriculum, but also program accreditation [17, 20]. Our findings also support the previous researchers' findings that AM leaders use of frameworks to operationalize their education curricula [12]. We additionally find that the AM program leaders in this study consistently collaborated with local industry leaders to ensure that AM programs produce the technical skills required in the workforce. AM college leaders first work directly with industry to identify the expected technical skills to include in their AM programs and then use existing AM frameworks to operationalize the previously identified technical skills in their curricula.

Study participants indicated that their programs used a range partnership to guide programming and certificate development. Participants emphasized that including a variety of stakeholders enabled them to offer directly impactful two-year engineering technology and engineering technician education. AM program leaders in this study consistently reported collaborating with industry to identify the technical skills that are in demand in their unique region to include in the AM programs and use existing AM frameworks to then operationalize these skills in their curricula. Although their target students differed, the participating program faculty and administrators agreed that offering highly technical programs in rural settings required advanced physical spaces; these spaces require an ongoing commitment to appropriate financial resources, variously obtained from the institution, local employers, or some combination of external source.

Physical AM spaces were key to establishing AM programs. A facility or a space for AM with current equipment for technical instruction emerged as an instrumental finding in this AM program analysis. Centralization of the facility, funding, and industry collaboration emerge as critical components to AM facilities. A centralized AM facility serves to accomplish curriculum goals by successfully preparing students with advanced technical skills through hands-on learning. In addition to a centralized space, Pink State College shared the importance of housing robust and current equipment within this space. Participants from Yellow State College shared

the importance of a centralized AM facility by citing its absence. A dean from Yellow State College shared the importance of place as a top priority because the AM programs are currently scattered at Yellow College. The dean spoke to the value that a centralized AM facility serves in the curricula by better physically connecting the equipment used in various courses to demonstrate the strengths of combined skillsets and workflow. Our findings from Pink State College indicate that the AM facility serves a role in meeting their specific curriculum demand from local industry leaders for more science, technology, engineering, and mathematics (STEM) based technical skills in graduates entering this workforce. Additionally, we found that the technical skills AM students gain using the specific machining equipment housed in Red State College's AM facility directly matched the equipment found in Red State College's local industry. We found that Green State College collaborated directly with industry leaders, and this collaboration served a critical role in identifying and securing the equipment used in Green State College's AM facilities and in shaping how the facilities grew over time. Green State College include the significance of a robust AM facility and the collaborations outside the AM program and institution. Our findings from Blue Community College further demonstrate the role of collaboration with industry in obtaining AM facility instructional equipment that prepares AM students with industry needed skills. In addition, we found that Blue Community College's AM leaders reported that much of the equipment in AM facilities is secured through grants.

We found that the AM program leaders in our rural Northwest Florida's AM programs study consistently reported both a small faculty and a relatively small student profile in their programs. The majority of the AM program leaders reported that a faculty of one with a small number of instructors are employed to support teaching in the programs. We find in this study that the complex challenge of faculty credentialing in AM programs is cited by AM leaders as a barrier to employing additional faculty. This faculty credentialing challenge is further discussed below in the challenges and priorities section. AM leaders in this study identify increasing student enrollment as a top priority. In addition to increasing student enrollment, AM leaders in this study identify improving AM program student completion rates as a top priority. An AM faculty member from Green College shared the challenges that metric based evaluations present to AM programs evaluation. For example, the Green College faculty member discussed an anecdotal example of how the success is lost for a student who leaves an AM program before completing the program but who gained enough skills during the student's time in the program to be gainfully employed. The anecdotal evidence shared by AM leaders in this study raise further questions regarding the policies that create AM program evaluations.

Challenges and Priorities

Leaders and faculty from each AM program consistently map their own programs top priorities to also presenting as their top challenges. This finding suggests that the top priorities AM leadership identifies are also perceived as a considerable challenge to accomplish. From our interviews, we learned that the programs had all been founded for a range of locally-driven reasons and included different stakeholders in their planning processes. All of the program leaders were challenged by building and maintaining appropriate credentialed and qualified faculty, and as a result, struggled with small faculties who were expected to cover large numbers of courses and duties. We learned from this analysis that many students enrolled in the programs

work full-time and thus tended to attend courses in the evenings. Increasing student diversity in the programs emerged as a common program goal.

We found that AM leadership experience a common top challenge in hiring faculty candidates who meet the credentialing definitions determined by regional accreditation bodies. The regional AM faculty requirement credential of holding a master's degree and 18 graduate hours is cited as a specific challenge by participants from all AM programs in this study. AM program leaders from this study explained the accreditation is particularly important for students who wish to pursue further academic degrees after completing their programs AS degree or certificate program. Accepting the student's credit from the AM program by the university the student wishes to attend is institutionally specific; however, meeting faculty accreditation standards is a core determinate in accepting the transferring credit.

Political factors affect institutional community and state colleges in Florida, the literature found that the 2008 Florida Senate Bill No. 1716 replaced the Florida Community College System with the Florida College System and by 2011, 21 of the 28 community colleges were approved for at least one baccalaureate degree [16], [17]. This literature finding in combination with the iterative discovery of the AM leadership and championship themes during a professional AM meeting raises additional questions regarding AM leadership roles and the policies that affect regional AM programs development [18], [19], [20]. For example, a comparative analysis of national and regional AM faculty accreditation policies might further the discussion of the recurring theme of small faculty. This small faculty profile is related to the rural Northwest Florida regional challenge of AM program leaders locating qualified applicants who meet the regional accreditation standards for employment. Additional state and federal government policies that also affect credentialing might be fruitful to include in this future study.

Additionally, this study's findings demonstrate the challenging effects that faculty turnover and leadership change have on AM program growth. The loss of even one instructor is particularly challenging with such small faculty and instructor profiles reported in this study. Institutional administration turnover is reported to slow the growth of AM programs in this study. For instance, while discussing AM program collaboration challenges, a department chair from Red College detailed the challenges of continuing a shared AM program goal and nurturing continued partnerships across multiple college level leadership changes.

Communicating the opportunities and value of AM programs is identified as of the top challenges all AM program participants expressed. This challenge includes enabling community stakeholders to not only be aware of their programs, but also accurately conveying the reality of current AM curricula.

Our study found securing funding to be a common priority and challenge among the AM leaders we interviewed. As with Yellow State College, Red State College identified the cost to maintain and grow their AM programs as a challenge and the importance of securing funding either through donations, funding, or institutional support a top priority to maintain AM facilities. Red State College further demonstrated the considerable cost and challenge associated with securing the specific technical equipment that is required for competitive AM program educational offerings. Red State College also demonstrated a specific challenge in securing this equipment

funding, particularly when grant sources are not easily secured resulting in competing for institutional funding support. Green State College additionally finds the key role that grant funding serves in obtaining equipment in AM facilities.

Conclusion

In this study, we performed “origin story” interviews to document that creation and evolution of five AM programs in rural state and community colleges in Northwest Florida. Our findings reflect that the participating colleges established and grew educational pathways tailored explicitly for the immediate community, and engaged in active participation between local stakeholders and industry—findings in line with the heritage of community college research. This study is significant because our findings suggest that AM program leaders, and indeed CTE leaders overall, have an opportunity to leverage their unique local foundation to distinguish themselves from competitors. Indeed, unified by the statewide curriculum frameworks and national industry models and directives, program leaders have an opportunity to work together on a cohesive core curriculum, and concentrate on differentiating content in response to local needs. Likewise, program leaders can collaborate to share strategies for working closely with industry, attracting full time students, maintaining state-of-the-art facilities, and addressing serious faculty shortage issues—all challenges common to regional programs.

Next steps for this research involve translating the findings for a number of practical audiences. For example, our works here suggest that that we should investigate best practices from other institutions that have successfully addressed the common challenges cited by participants. Our themes also suggest that we may be able to distill AM program development models to help prospective program leaders understand how to plan for and sustain dynamic, effective AM learning opportunities. Finally, challenges relating to faculty shortage pose policymaking implications for state and national education stakeholders; we have an opportunity to explore the extent to which faculty shortages affect AM program development nationwide and how the faculty pipeline might be best strengthened and lengthened.

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Appendix

AM Origin Story Interview Protocol

Origin Story Protocol

Please remember to record the interview!

Partner Name: _____ Date: _____

1. When was your program founded?
2. Why was your program founded? (Listen for environmental factors, institutional factors)
3. How was the curriculum developed? (Listen for who designed the curriculum, external stakeholders who provided input)
4. Tell me about your faculty. How were they selected for the program? (Listen for existing faculty, criteria for recruiting new faculty, value of industry experience, faculty educational backgrounds)
5. Tell me about your students. How are they recruited? (Listen for major changers, students who come especially for the program, career changers/retraining) What do you think attracts students to your program?
6. What do you think are the unique features that your program offers faculty, students, and the community?
7. How does your institution evaluate your program? (Listen for advisory board, accreditation, student input)
8. What do you see as the biggest priorities for your program in the next 5 years, 10 years?
9. What do you see as the biggest challenges facing your program in the next 5 years, 10 years?
10. Is there anything else I should know about your program?