127th ASEE Annual Conference
June 21-24, 2020 | Palais des congrés de Montréal | Montréal, Canada
Paper ID #29185

Building a Comprehensive Collaborative Infrastructure to Create Instrumentation Workforce Pathways

Ms. Alicia Boudreaux Kiremire PE, PMP, FlowStream Management LLC

Ms. Kiremire is a grant management consultant specializing in large, collaborative STEM education grants. She holds degrees in both engineering and education and has over 13 years of professional experience.

Dr. Michael K. Swanbom PE, Louisiana Tech University

Dr. Swanbom is a Distinguished Lecturer in Mechanical Engineering. He is a developer of innovative, hands-on, practical content for both high school and university curricula. See his lectures at: https://www.youtube.com/c/TheBomPE

Mr. Gerry Caskey, Louisiana Delta Community College

Mr. Caskey is the Instrumentation Instructor at LDCC Ruston Campus with over 30 years industry experience. As the Principal Investigator for the NSF funded grant "Project Complete", he is passionate about introducing Instrumentation as a career pathway for the next generation.

Barton Crum, Applied Research for Organizational Solutions (AROS)

Ms. Crum is a doctoral candidate in the Industrial and Organizational Psychology program at Louisiana Tech University. She currently serves as the Student Director of AROS and holds the roles of project manager and associate on several projects with both private and public sector clients.

Miss Juliette Pate, Louisiana Delta Community College

Ms. Juliette Pate is a Grant Coordinator who specializes in recruiting, dissemination, external engagement, and student bridging efforts. She holds a degree in Marketing from Louisiana Tech University and is currently in the process of completing her Master's.

©American Society for Engineering Education, 2020

Building a Comprehensive Collaborative Infrastructure to Create Instrumentation Workforce Pathways

Abstract

This paper presents the work of a two-year community college building a comprehensive collaborative infrastructure with a research university, seven high schools, and five industry partners in North Louisiana. The five main goals in this collaborative infrastructure were establishing (1) a management structure, (2) one primary high school partner, (3) two academic transfer agreements, (4) an Industrial Advisory Board of three members, and (5) seven additional high school partners to scale future implementation.

Three of these goals were fully accomplished within the planned timeline, and the two others were partially accomplished. This paper discusses detailed achievements in each area along with the project's external evaluation results and the project leadership team's lessons learned. The partnership infrastructure that has been built will be used to build the skilled technical workforce in North Louisiana through increasing high school students' awareness of and preparation for careers in instrumentation and manufacturing.

This material is based upon work supported by the National Science Foundation's Advanced Technological Education Program under Grant #1801177. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Rationale for Project

The United States workforce faces a shortage in skilled workers, especially in jobs requiring industry relevant skills but not necessarily four-year degrees. According to a report by the National Academies of Sciences, Engineering, and Medicine, 3.4 million skilled technical jobs are expected to be unfilled by 2022 [1]. Additional labor predictions through 2024 show that for every ten jobs, only three will require a bachelor's degree or higher [2].

In this project's state, Louisiana, skilled workers are the backbone of our most important industries. Louisiana Economic Development has identified nine key industries in Louisiana [3], and six of those nine industries rely heavily on automation technology and skilled technicians. In addition, the North Louisiana Economic Partnership (NLEP) has named Advanced Manufacturing as a target sector for North Louisiana. Since 2014 NLEP has hosted an annual Manufacturing Week, and in 2019 over 1,300 high school students visited over 50 manufacturing and training facilities in North Louisiana to learn about occupation needs and possible careers [4].

These occupation and skill needs have changed as automation technology has grown in rural North Louisiana; namely, more employers are asking for “multicrafted” workers. For instance, mechanical assembly positions require more wiring skills; and electrician positions require more knowledge about instrumentation and controls. Our team conducted a local industry survey on required workforce skills, which yielded skills such as calibration, troubleshooting, safety, and quality. Many of these skills compare to the “Automation Competency Model” developed by The Automation Federation (AF) and the U.S. Department of Labor [5].

To compound the workforce needs caused by new technology, large numbers of experienced, knowledgeable workers are retiring, leaving urgent workforce gaps. Traditionally, technicians and engineers could spend up to two years in training once they started an entry-level job. However, in today’s high-tech industries, employers cannot afford a two-year training delay. This indicates that education should be more closely aligned with industry activities and workforce needs.

Project Approach

In order to meet these urgent workforce needs, a report by the National Academy of Engineering, *Building America’s Skilled Technical Workforce*, calls for a **“network-centered approach”** where “students, guidance counselors, workers, business owners, manufacturers, labor leaders, school administrators, and community college teachers [work] together to create local solutions” [6]. Specifically in automation-related fields, a network-centered approach is also optimal for addressing the multi-faceted competencies in the “Automation Competency Model” introduced above [5]. Our project follows this network-centered approach, partnering across organizations and taking advantage of the resources available to students in our local area. See Figure 1.

Specific partnerships recommended by the National Academy of Engineering report *Community Colleges in the Evolving STEM Education Landscape* are two-year colleges with four-year colleges/universities [7]. As such, the primary partners in this project include Louisiana Delta Community College (LDCC) and Louisiana Tech University (LA Tech).

LDCC has a strong Industrial Instrumentation Technology program based in Monroe, LA, with a newly created program at its Ruston, LA, campus. Across all campuses, the program has relationships with over 20 local manufacturing companies. Educational facilities include a 4,700 sq-ft instrumentation lab housing trainers valued at over $1.1 million, a majority of which has been supplied by industry partners.

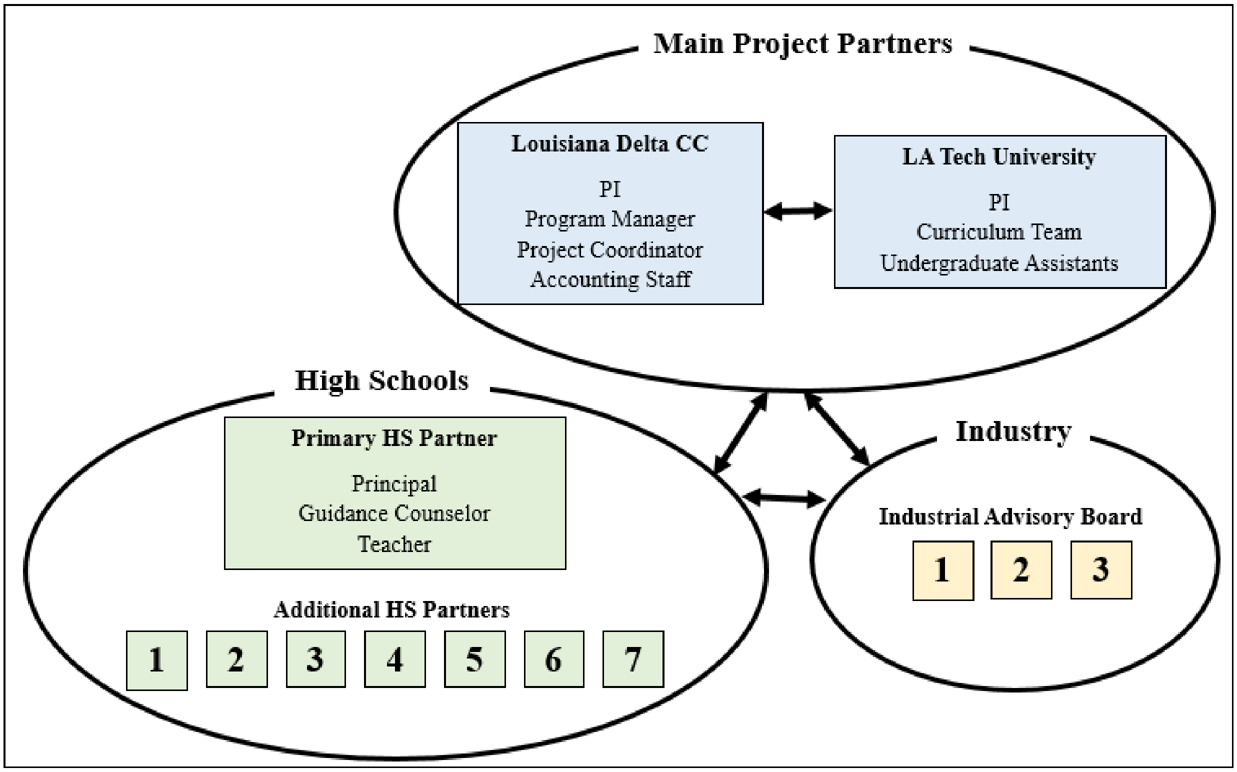

Figure 1: A Network-Centered Approach.

LA Tech is a four-year research university based in Ruston, LA. LA Tech offers a bachelor's degree in Instrumentation & Control Systems Engineering Technology that covers a combination of engineering theory, mathematics, and hands-on applications. LA Tech maintains strong relationships with many area high schools and has developed grant-funded curricula for high school and college freshman audiences (NSF Grant #0618288, NASA Grant #NNX09AH81A). These curricula are hands-on, project-based, and build such workforce skills as confidence, communication, innovation, product design, and lifelong learning [8 - 13]. Application- focused student experiences have continued to expand over the past ten years through ongoing assessment and evaluation by the Industrial Advisory Boards overseeing LA Tech's ten engineering and engineering technology programs.

Collectively, the two partners' experience in instrumentation technology education, industry and educational partnerships, and curriculum development were a strong foundation upon which to build the current project.

Project Goals

The project's overarching goal was to **build a comprehensive collaborative infrastructure** for piloting an instrumentation workforce development program to address manufacturing workforce challenges. This collaborative infrastructure included:

1) **Developing a management structure** for the two primary partners to communicate and manage the project. This was important, as the two institutions had never worked together on a collaborative grant.
2) **Establishing a primary high school partner** who would work with LDCC and LA Tech to build a high school instrumentation course which could be scaled and adapted at other high schools around North Louisiana.
3) **Developing a dual enrollment agreement** for LDCC and partner high schools/districts **and an articulation agreement** between LDCC and LA Tech for the instrumentation course referenced in Goal 2 above.
4) **Forming an Industrial Advisory Board** with at least three members, establishing effective communication methods, and offering convenient ways for them to support the project.
5) **Soliciting partnerships with seven additional partner high schools** in which to pilot the program.

Milestones Completed

The five goals listed above were met by the project team to various extents (see Table 1).

Goal	Accomplished?	On Time?
1. Management Structure	Yes	Yes
2. Primary HS Partner	Yes	Yes
3. Transfer Agreements	Partially	No
4. Industrial Advisory Board	Yes	Yes
5. Additional HS Partners	Mostly	Yes

Table 1: Milestones Completed.

Goal 1, Management Structure: This goal was accomplished during the first year of the project. Roles and responsibilities were divided based on strengths and interests of the four managing team members: LDCC first Principal Investigator (PI), LDCC second PI, LA Tech PI, and a contracted Program Manager. The project's initial PI was an LDCC campus administrator strong in relationships internally and throughout the community, so he communicated with these various groups as the project's foundation was being built. Midway through the project that PI left the college, and LDCC's new PI contributed his 20 years of industry and teaching experience to curriculum development in addition to growing in administrative communications across his campus. The LA Tech PI brought over 12 years of experience in teaching and curriculum development, so he led the curriculum development team. Finally, since the two LDCC PIs were both new to NSF projects, LDCC contracted with a program management consultant to provide support and mentorship in grant management.

The project team was spread across three different campuses, so it was important to establish solid communication processes early in the project. The project's leadership team started with face-to-face monthly management meetings, which was increased to bi-weekly meetings in Year 2 as the project grew and required more coordination in various areas. The project's curriculum sub-team also held weekly face-to-face meetings to coordinate their task-level work. The teams also communicated by email and/or phone when needed between meetings.

Another important management task toward the beginning of the project was to set up relevant subcontracts and accounting processes between the two primary partners. This required more coordination and time than was expected, but ultimately the team built relationships with staff across the campuses to set up processes for the remaining lifetime of the project.

A third management milestone was recruiting and hiring a dedicated Project Coordinator. The rest of the management team was already in place at the beginning of the project, to set the foundation of the project as described above. As the project needed more event coordination, marketing materials, a project website, and outreach to various high schools, the management team used their current and past professional relationships to identify the right person for Project Coordinator. This Coordinator's strengths and background were a fantastic fit for the project, and her role has been valuable among a team of technically trained faculty.

Finally, throughout the project, the team met quarterly with the external evaluation team for updates and feedback (see "Project Assessment" section below for more details on this feedback).

Figure 2: Planning Workshop

Goal 2, Primary High School Partner: This goal was accomplished during the first year of the project, as the Bossier Parish School for Technology & Innovative Learning (BPSTIL) was added to the project team. The school's Principal, Counselor, Math Teacher, and Engineering Teacher all gave invaluable feedback throughout the project's timeline on curriculum development, marketing strategy for high school administrators, and marketing strategy for high school students/parents Most of these discussions took place in face-to-face planning workshops, as shown in Figure 2, along with email and phone communications as needed.

In curriculum development, BPSTIL's teachers helped the project's curriculum team to finalize a course topic list that would meet LDCC, LA Tech, and BPSTIL requirements. The teachers also discussed with the team the best hands-on project platform for students to build circuits, eventually deciding on the Arduino platform. This allowed the project's curriculum team to adapt Arduino tasks and projects for use at the high school level and to assemble project kits that would be provided to all partner high schools.

On the lessons themselves, in the form of PowerPoint slides, the curriculum team and BPSTIL teachers engaged in a feedback process using a Google Team Drive and online feedback forms for each lesson. For example, one recommendation made by a partner teacher was to add learning objectives and real-world examples to each lesson. The curriculum team was able to use this as formative feedback when creating remaining lessons as well as improving on the lessons that had already been evaluated by the teachers.

When discussing a marketing strategy for other high school *administrators*, BPSTIL's Principal and Counselor were especially helpful. Adding an entire new course in a high school's current curriculum and funding plan would be a challenge, but we learned that Louisiana high schools desire "points" toward their annual grading calculation. One thing that will earn points for schools is offering a course within a "Jump Start" pathway, which is an initiative by the Louisiana Department of Education to better prepare high school students for local high-need, high-wage career paths upon graduation. Our BPSTIL partners identified Louisiana Course Code 110600 "Basic Electricity and Electronics," which qualifies as a technical course in many Jump Start pathways. Another course characteristic that will help a school earn points is an Industry-Based Certification (IBC). The BPSTIL partner teacher used his industry knowledge, relationships, and sheer brilliance to find a relevant IBC (Electrician's Helper) and pair it with the project's course, filling the few content gaps that would complete all IBC requirements. Finally, BPSTIL recommended that other schools consider pairing the course with a "core" math or science course to help with conflicts in students' very tight academic schedules.

As the project team worked to make the full course a good fit for high schools, we also realized that we would need to provide a clear option for modular use of the curriculum for schools who were not yet able to fund a teacher to implement the full course. These schools could use lessons and projects as they relate to current state science standards, which include a renewed focus on engineering, technology, and applications of science [14, 15].

When discussing a marketing strategy for high school *students*, BPSTIL's Counselor and Math Teacher discussed with our team a list of "frequently asked questions" that students or parents would have. This included a detailed discussion recommended by the National Academy of Engineering "about the similarities and differences between the two variants of engineering [two-year and four-year] and how they might complement one another while serving the interests of a diverse student population" [16]. Our Project Coordinator was able to use information from this discussion as the basis of the project's website [17].

BPSTIL partners also recommended the best student groups to target for our project: current "construction" students (welding, carpentry, etc), students who choose not to continue in a pre-engineering program past the second class, robotics teams, Cyber Literacy II classes, Trigonometry, Advanced Math, Algebra II, and Algebra I students. This list could later be adapted to each school and/or school district with whom we met, depending on the courses and after-school activities offered at each school.

When selling the instrumentation career to all of our target market groups, the team's initial strategy used tag lines such as "pays well," "high-tech," and "saves money." However, these phrases were too vague to audiences completely unfamiliar with automation or engineering technology. The BPSTIL group shared that people need stories with which to connect. Therefore, the grant team began using different language in introducing the program, including specific stories and examples such as: using computers to cut a large log into various size pieces, controlling the temperature of water in a chemical plant, and using sensors in a self-driving car to decide when to stop. The group also contrasted the number of instrumentation technician/supervisor jobs and engineering jobs in a 60-mile radius: if parents want their students to remain in the area, instrumentation technology is a good field!

Finally, when discussing who has the best contact with students and their career opportunities, the BPSTIL partners helped us to realize that counselors may have too many students to work one-on-one with each student and his/her career path. The group recommended we include math/science teachers not only to teach the course topics but also for the recruiting and career awareness goals of the grant.

All of these valuable discussions and recommendations by BPSTIL prepared the team to move forward with creating a larger, more comprehensive collaborative infrastructure with North Louisiana high schools, as described below.

Goal 3, Transfer Agreements: This goal was partially accomplished in Year 2 of the project (initially planned for Year 1). Figure 3 shows the two agreements supported by the project.

For the first instrumentation career pathway, a two-year Industrial Instrumentation degree at LDCC, a dual enrollment agreement needed to be created for high school students who would complete the full instrumentation course at one of our high school partners to receive dual enrollment credit for the first two courses in LDCC's Industrial Instrumentation program. Dual enrollment agreements for all schools in the Louisiana Community and Technical College System follow a standard format, and LDCC already had signed agreements with several districts in North Louisiana. We did not expect many challenges with this goal, so the team waited until a majority of the high school curriculum was created before pursuing the draft dual enrollment agreement. In mid-Year 2 of the project, the agreement was finalized and signed by BPSTIL's District Superintendent.

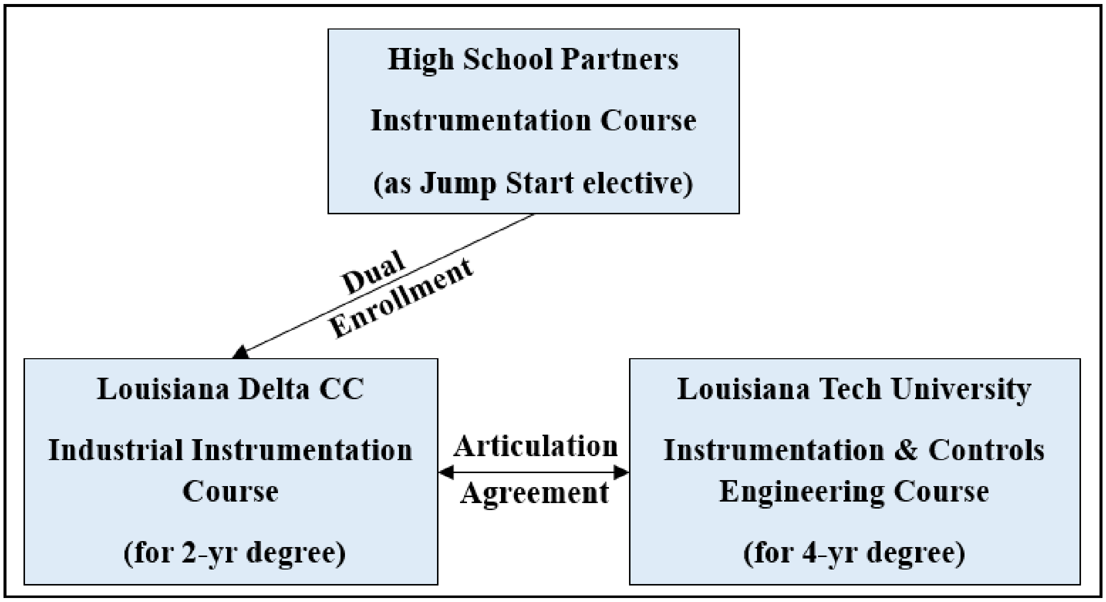

Figure 3: Transfer Agreements.

For the second pathway to an instrumentation career, a four-year ICET degree at LA Tech, the team had planned an articulation agreement wherein high school students who earn LDCC credit for the two courses referenced above can transfer that credit to LA Tech, as the first course in its ICET program. This goal has not yet been achieved but is still planned.

Goal 4, Industrial Advisory Board: This goal was achieved during the first year of the grant. The Advisory Board started with three companies and grew to include five companies. The project leadership team has hosted face-to-face and conference call meetings, in addition to email and phone communications with industry advisors.

Industry relationships have yielded a variety of benefits for our program. Feedback from industry was needed during the curriculum development process to connect the curriculum to employability skills such as hard work, interest in the field, ambition, listening, and punctuality. Desired field-related skills according to our Industrial Advisory Board included fundamentals of basic electrical work, PLC logic programming, instrumentation technician skills, and robotics.

Industry advisors also shared quotes about the local workforce need and benefits of a career in instrumentation, which were used in press releases and marketing materials. The project offered Manufacturing Week; see Figure 4, where high school students visited a local industrial site and industry field trips for high school students through the North Louisiana Economic Partnership'ssaw instrumentation in action. One industry partner donated $5,000 in scholarships for high school students who pursue an instrumentation career at LDCC or LA Tech. Finally, several industry advisors provided PowerPoint slides highlighting their companies that can be used in high school partner classrooms.

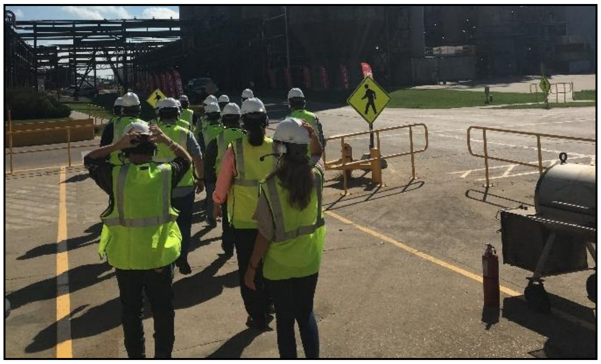

Figure 4: Industry Site Tour.

Goal 5, Additional High School Partners: This goal was partially completed, as the project partnered with six of the seven high schools originally planned. Several factors contributed to successful partnerships. First, sharing the marketing points recommended by BPSTIL (discussed above) helped the project team to connect with the culture and needs of local high schools. Second, offering stipends to teachers and counselors to attend workshops helped to make their participation worthwhile among all their existing responsibilities and commitments. Figure 5 shows one of the six workshops the project hosted for high school teachers and counselors. Third, the team used a "dual approach" for marketing to high schools, which included both a "top-down" strategy of meeting with school district administration and a "bottom-up" strategy of presenting at high school teacher conferences in order to meet interested teachers.

The team was met with several challenges when recruiting new high school partners. First, several of our rural school partners experienced teacher turnover, which made it difficult for some schools to follow through on their desire to participate. The teachers who did stay in the program needed more resources than we provided, which is discussed more in the "lessons learned" section below. Second, related to our dual marketing approach, the team learned that for a successful partnership both teacher and administrator must be supportive of the project's goals and activities. Finally, though the project sought to increase diversity in the instrumentation field as one of its goals, diversity of teachers and students was not an automatic result of our recruiting, even in a diverse geographic region.

Figure 5: High School Teacher/Counselor Workshop.

Ultimately, each high school partner chose the level of participation that fit their school best. Our primary partner, BPSTIL, chose to implement the full instrumentation course for dual enrollment credit. Another school implemented the full course, but not at a college dual enrollment level. The remaining five schools participated in the project's career development activities such as field trips and workshops, along with using our project kits and lesson modules to meet standards in their high school core courses such as Physical Science. Several of these schools desire to implement the full course in the future but need strategic assistance to fit their school's specific situation with state requirements and funding incentives. In this case, it has been beneficial to share BPSTIL's successful implementation strategies and facilitate conversations among other high school administrators.

Project Assessment

The project's assessment was performed by an external evaluator, AROS Consulting. The results presented below have been extracted from two separate external evaluation reports provided by AROS and are based on qualitative methods such as artifact review, participant surveys, and stakeholder interviews.

The evaluation process included maintaining regular communication with the project leadership team through email correspondence and in-person meetings. Quarterly meetings allowed the project team to provide information on developments regarding the following: acquisition of partner schools, curriculum development, articulation agreements, dual enrollment processes, marketing, and dissemination. The information was verified by extensive meeting minutes from meetings between the project team and all relevant entities. In addition to providing access to these meeting minutes, the evaluation team was invited to attend a curriculum development workshop and a meeting with a potential high school partner. The evaluation team was also given access to a cloud storage folder specifically created to hold project resources developed by the project team. The folder includes meeting agendas, meeting minutes, program planning timelines, and course curriculum information. Documents from the cloud storage folder were cross-referenced with notes taken by the evaluation team during meetings with principal investigators to assess this year's progress.

Later in the project, AROS administered a survey to teachers and counselors who had attended workshops. The evaluators also held interviews by phone or in person with industry partners, high school partners, and project team members.

Results from Year 1 evaluation showed that project management meetings facilitated coordination of team members, such that each team member was able to share their recently completed work and focus on next objectives. Most of the work allowed team members to work independently, but more frequent meetings were recommended once curriculum implementation began at partner schools. With this iteration being the first for the project, a considerable amount of work was put into the planning stages of the program. The project team from the different universities was able to effectively communicate with each other to develop a plan for recruiting a partner school, to successfully disseminate program accomplishments, to move forward with articulation agreements, and to create a framework and plan of action for finalizing the high school course curriculum.

Year 1 evaluation also confirmed that the development of the high school instrumentation course incorporated elements and guidance from a number of sources, including an industry recognized curriculum, high school teacher opinions, requirements for the curriculum set forth by both LA Tech and LDCC, curriculum development team of various college-level professors, and industry contacts. It is important to note that the team proposed that curriculum pilot testing in a high school would take place during Year 1 of the project. The project team decided to move the pilot testing of the curriculum into Year 2 because they were unable to find an appropriate and available high school course during Year 1 to use as a testing platform.
During Year 1, the process for establishing the articulation agreements has begun at both institutions, as well as the process of developing a dual enrollment agreement between LDCC and a local school board. Although the project team had not secured the signed agreements between institutions and between the school board in Year 1, this was expected to occur in the following few months.

As of the end of Year 1, the project team had one committed member in place on their advisory board and is actively pursuing more members. Prospective members had been contacted through email, in-person meetings, and surveys in order to obtain their input and drive program improvement. The team would utilize the advisory board's expertise to inform the content of the program.

Year 1 evaluation noted that the acquisition of partner high schools is critical to the success of the project. It was therefore noteworthy that the project team already has one school, BPSTIL, engaged in the project. Furthermore, BPSTIL was integral in the development of the curriculum and provided valuable insight into potential future dissemination processes. The team was on track to secure more partner schools in the coming months and was actively trying to address the concerns brought forth by high schools that were not able to commit to the program.

Overall, AROS evaluation showed that the first year of the project was successful in pursuing the goals outlined by the grant proposal. Although the first year did have some small setbacks (e.g., partner school acquisitions, finalizing an advisory board, pilot testing the curriculum), the project team was on track to establish the program's foundational framework in the few months following the evaluation report. The team had also begun to brainstorm ideas for a training workshop for prospective teachers, counselors, and administrators once the curriculum had been finalized. In addition, AROS noted that the curriculum team was quick to incorporate any curriculum feedback received from both high school teachers and industry partners.

Evaluation results shared by AROS during Year 2 comprised of formative feedback for the remainder of the project. A feedback survey from a teacher/counselor workshop showed that the project's purpose was clearly communicated and that participants planned to advocate for the project at their school. Teachers and counselors identified areas for improvement such as extended breakout session length during workshops, a larger focus on curriculum content, and more supplemental materials provided by teachers to better support their teaching of the course. Workshop participants requested follow-up workshops where teachers could learn more about instrumentation course content and how to teach it, and teachers/counselors could learn more about using the course to secure Jump Start funding from the Louisiana Department of Education. AROS recommended that the team provide information on how partner schools can integrate the curriculum into course offerings and consider a "flipped classroom" approach to future workshops.

Formative feedback regarding communication with stakeholders included maintaining more personal communication with teachers and counselors (e.g., personalized emails) and sending regular project updates to both industry and school partners. Regarding industry and school recruitment, the evaluators recommended that the project team prioritize in-person contact, provide program resources for dissemination by partners, provide schools with information on the Jump Start connection, and involve the curriculum team in the recruitment process.

Regarding student recruitment and project awareness, formative feedback included exploring the project's current student base; providing potential students with physical program information (e.g., pamphlet, newsletters, etc.); marketing at robotics competitions, career fairs, etc.; instructing industry partners to advertise the project; and considering more on-site presentations of the project (at high school partner sites). Regarding the Industrial Advisory Board, the evaluator recommended that the team meet with the industry partners to clarify purpose and to strengthen relationships, utilize the industry board in more project functions, involve industry partner companies in school interactions, and connect outcomes of the project to opportunities at industry partner companies.

Finally, regarding project team coordination, the evaluator recommended investigating the addition of an LDCC employee to handle administrative functions, clearly defining the new PI's role, continuing bi-weekly meetings to maintain traction, creating and upholding realistic goals, and creating a task list to ensure accountability and to increase goal awareness.

This formative feedback from the project's external evaluator was used throughout the rest of the project to meet project goals and continually improve the team's work in building a comprehensive collaborative infrastructure with each other, high schools, and industry partners.

Lessons Learned for Two-Year College Collaboration

In addition to the recommendations from the project's external evaluator, listed above, the project team would share the following lessons learned with our colleagues at other two-year colleges who are building collaborative infrastructure with universities, high schools, and industry partners:

Regarding partnerships with *universities*, especially on large multi-year grant projects, start work as soon as possible after the grant period starts. "Year 1 tasks" associated with setting up a project, team, accounting processes, etc, take longer than may be expected and can easily cut into time that should be spent actually accomplishing the grant's specific goals. A second lesson is to discuss roles and responsibilities for each person on the team. This should be done immediately when the project is funded, and likely in more detail than was communicated in the project's grant proposal. Our team also found it helpful to revisit this conversation each year, as team members' roles may change depending on the project's work that year. Third, we have experienced more turnover on our core project team and with several partners than we expected, which makes written documentation such as meeting minutes and emails especially important. Finally, our team has learned to be creative to overcome barriers, while also being aware of "scope creep" that can unnecessarily grow a project outside its original scope. In this case, we have begun discussions about potential follow-up projects.

Regarding partnerships with *high schools*, one lesson is to become knowledgeable about the larger "political landscape" of high schools, including state Department of Education strategies/incentives and administrator needs. Simple interest in the project is not enough for high schools to commit to participating. Second, we learned that recruiting for diversity needs to be intentional. This can be done either by seeking partnerships with minority-serving high schools and/or by discussing diversity initiatives with teachers and counselors at all partner schools. Finally, we learned to consider credentialing requirements more seriously when seeking to implement a dual enrollment course. In our partnership model, high school teachers teach the course we have created. This is largely because our partners are spread across a 90-mile radius in several rural areas, and it would be difficult to bus their students to a single community college campus for the course. However, rural high schools do not often employ teachers with instrumentation degrees or industry experience, which we realized was a credentialing requirement of LDCC for our dual enrollment course. This need was also reflected in many teachers' lack of confidence when attempting our lessons and their requests for more support and resources than we had originally planned to provide. Our team is considering a video model in the future, where LDCC faculty could possibly lead a distance dual enrollment course for high school students in rural areas.

Regarding partnerships with *industry*, our main lesson learned is to consider specific ways industry partners can support the project and not to assume meeting as a group is the best and/or most effective way to partner. This lesson was informed by the very helpful Working Partners Research Project, which is funded by the National Science Foundation Advanced Technological Education (ATE) Program and "seeks to discover, document, and disseminate the key factors and core practices associated with industry/college partnerships within the ATE community." The Working Partners research lists eight ways to partner with industry (only one of which is an Advisory Board), along with best practices for each partnership method [18]. Our team learned that our industry partners want specific ways to be involved, such as visiting high schools, sharing marketing materials in their communities, and funding scholarships. Meeting twice a year is not as practical for them, but they can support the project just as well (or even better) through individual, concrete actions throughout the year.

Summary

In this project, a two-year community college built a comprehensive collaborative infrastructure with a research university, seven high schools, and five industry partners in North Louisiana in order to implement an instrumentation workforce development program. Through setting up intentional processes, agreements, and discussions, the project team has been successful in creating a collaborative infrastructure that will benefit not only the workforce development program at hand, but also future projects in support of North Louisiana's skilled technical workforce.

References

[1] National Academies of Sciences, Engineering, and Medicine (NASEM), "Building America's skilled technical workforce," The National Academies Press, Washington, D.C. 2017. [Online]. Available: https://www.nap.edu/catalog/23472/building-americas-skilled-technical-workforce. [Accessed Jan. 31, 2020].

[2] National Center for Construction Education and Research (NCCER), "Restoring the dignity of work: Transforming the U.S. workforce development system into a world leader." [Online]. Available: http://www.nccer.org/news-research/research/rt335. [Accessed Jan. 31, 2020].

[3] Louisiana Economic Development (LED), "Key industries." [Online]. Available: https://www.opportunitylouisiana.com/key-industries. [Accessed Jan. 31, 2020].

[4] North Louisiana Economic Partnership (NLEP), "Manufacturing week." [Online]. Available: http://www.nlep.org/Workforce/Manufacturing-Week.aspx. [Accessed Jan. 31, 2020].

[5] R. Arcot, "Workforce development: Automation competency model serves emerging industry and professional needs" *InTech Magazine*, 2013. [Online]. Available: https://www.isa.org/standards-publications/isa-publications/intech-magazine/2013/august/workforce-development-automation-competency-model-serves-emerging-industry-and-professional-needs/. [Accessed October 1, 2017].

[6] National Academy of Engineering and National Academies of Sciences, Engineering, and Medicine, “Building America's skilled technical workforce: Consensus study report,” 2017. [Online]. Available: https://www.nap.edu/read/23472/chapter/1. [Accessed Oct. 1, 2017].
[7] National Academy of Engineering, S. Olson, and J. Labov, “Community colleges in the evolving STEM education landscape: Summary of a summit,” 2012. [Online]. Available: https://www.nap.edu/read/13399/chapter/1. [Accessed Oct. 1, 2017].
[8] C. Swafford, M. Orr, and D. Hall, “Building confidence through hands-on activities,” in *Proceedings of the American Society for Engineering Education Gulf-Southwest Conference*, Tulane University, 2014. [Online]. Available: http://www2.latech.edu/~dehall/LWTL/home/reports_and_papers/papers_and_posters/2014_ASEE_GSW_Building_Confidence_through_Hands_on_Activities.pdf. [Accessed Oct. 1, 2017].
[9] H. Tims, K. Corbett, G. Turner, and D. Hall, “NASA-Threads: A hands-on, context based approach to a high school STEM course,” in *Proceedings of the American Society for Engineering Education Annual Conference and Exposition*, 2010. [Online]. Available: https://peer.asee.org/poster-nasa-threads-a-hands-on-context-based-approach-to-a-high-school-stem-course.pdf. [Accessed Oct. 1, 2017].
[10] K. Crittenden, D. Hall, J. Barker, and P. Brackin, “First-year design experience: Assembling the "big picture" through innovative product design,” in *Proceedings of the American Society for Engineering Education Annual Conference and Exposition*, 2009. [Online]. Available: http://www2.latech.edu/~dehall/LWTL/home/reports_and_papers/papers_and_posters/2009_ASEE_design.pdf. [Accessed Oct. 1, 2017].
[11] D. Hall, S. Cronk, P. Brackin, J. Barker, and K. Crittenden, “Living with the Lab: A curriculum to prepare freshman students to meet the attributes of ‘The Engineer of 2020,’” in *Proceedings of the American Society for Engineering Education Annual Conference and Exposition*, 2008. [Online]. Available: http://www2.latech.edu/~dehall/LWTL/home/reports_and_papers/papers_and_posters/2281_LIVING_WITH_THE_LAB__A_CURRICULUM_TO_PRE.pdf. [Accessed Oct. 1, 2017].
[12] D. Hall, S. Cronk, J. Nelson, and P. Brackin, “The facilitation of lifelong learning skills through a project-based freshman engineering curriculum,” in *Proceedings of the American Society for Engineering Education Annual Conference and Exposition*, 2009. [Online]. Available: http://www2.latech.edu/~dehall/LWTL/home/reports_and_papers/papers_and_posters/2009_ASEE_lifelong_learning.pdf. [Accessed Oct. 1, 2017].
[13] D. Hall, H. Hegab, and J. Nelson, “Living WITH the Lab - A freshman curriculum to boost hands-on learning, student confidence and innovation,” in *Proceedings of the 38th ASEE/IEEE Frontiers in Education Conference*, 2008. [Online]. Available: http://fie-conference.org/fie2008/papers/1808.pdf. [Accessed Oct. 1, 2017].
[14] Louisiana Department of Education, “Louisiana believes: Science standards,” 2017. [Online]. Available: https://www.louisianabelieves.com/docs/default-source/district-support/science-standards- march-2017.pdf?sfvrsn=7. [Accessed Oct. 1, 2017].
[15] Louisiana Department of Education, “BESE Committee approves updated state science standards,” 2017. [Online]. Available: https://www.louisianabelieves.com/newsroom/

news-releases/2017/03/07/bese- committee-approves-updated-state-science-standards. [Accessed Oct. 1, 2017].
[16] National Academy of Engineering, Committee on Engineering Technology Education in the United States, K. Frase, R. Latanision, and G. Pearson, "Engineering technology education in the United States: Consensus study report," 2017. [Online]. Available: https://www.nap.edu/read/23402/chapter/1. [Accessed Oct. 1, 2017].
[17] J. Pate, "Project COMPLETE website," 2019. [Online]. Available: www.completepathways.com. [Accessed Jan. 31, 2020].
[18] R. Bower, E. Almasy, C. Halpin, and M. Slowinski, "Working Partners research project summary," 2018. [Online]. Available: https://www.workingpartnersproject.org/files/theme/resources/WorkingPartnersResearchProjectSummary2018.pdf. [Accessed Jan. 31, 2020].