Establishing and Engaging Collaborative Partnerships for Sustainable Technician Training Project Implementation

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Abstract: Collaboration with industry and other partners is a critical component of many Advanced Technological Education (ATE) projects, including the Central Coast Partnership for Regional Industry-Focused Micro/Nanotechnology Education (CC-PRIME) project at Santa Barbara City College (SBCC). This project includes partnerships and collaborative efforts with various entities, including local industry, national ATE Centers, and regional business and community partners. Challenges around identifying partners and defining structures to engage with them on an ongoing basis are described as important lessons learned from the initial development of the project. Tools and resources are outlined for successful project implementation by connecting with industry through an existing and heavily utilized shared cleanroom facility, and National ATE Centers and other ATE-funded projects for access to shared resources and tools. Additional partners for potential awareness, outreach, and recruitment efforts are identified, and efforts to sustain collaborative initiatives with all project partners are outlined in the context of further expanding the local micro nanotechnology training opportunities in the future.

Keywords: micro nano technology, collaborative partnerships, industry partners, technician training, local workforce

Introduction

The Central Coast Partnership for Regional Industry-Focused Micro/Nanotechnology Education (CC-PRIME) [1] is a collaborative project between Santa Barbara City College (SBCC) [2], the University of California Santa Barbara (UCSB), and local industry partners. This National Science Foundation (NSF) Advanced Technological Education (ATE) project seeks to address a regional workforce development challenge, working with industry partners to develop technician training for micro nano technology and semiconductor manufacturing jobs in the area [3]. The initial project goals are to (1) build industry visibility and relations within the community, (2) provide SBCC students and faculty with training and experiences in manufacturing at the university cleanroom facility, and (3) to create a student educational pathway to acquire semiconductor manufacturing jobs, incorporating industry input [1].

The National Science Foundation ATE program targets improvements in the education of science and engineering technicians [4]. While its focus is on two-year institutions, projects are strongly encouraged to include partnerships between academic institutions and industry, as well as economic development agencies, in order to be initially successful and sustainable in the long run beyond the grant project period [4].

Working early on and directly with companies operating in the fields for which a particular training program is designed is critical for its long-term success. One main metric for success is if many of its graduates ultimately obtain jobs in the field or are able to utilize their newly obtained skills in their existing jobs, as may be the case for upskilling participants. That, in turn, means that the training must meet industry needs to a large extent. In order to ensure that, industry input and collaboration are needed from the beginning of the project [5], [6]; this includes the identification of need, a potential gap analysis, and the curriculum development or corresponding modifications [3], [7], [8].

The project design and its initial implementation involved collaborating with various partners, including industry, a cleanroom facility at a nearby four-year institution, national ATE Centers, and regional community partners [1]. Approaches to identifying and working with partners from industry and other entities that have been encountered during the development of this micro nano technology cleanroom training program are described below. This includes experiences working with various collaborators, their impact on the project, lessons learned, and efforts around sustaining those collaborations.

Methods

Identifying Potential Industry Partners

Identifying potential industry partners for a workforce development project can be challenging. Some companies may be identified easily due to their main line of work being directly aligned with the targeted workforce area, while others may be less obvious [9]. They may need technicians with similar skills, even though their main line of work may be in a different field or not directly related to the specific employee's job duties [3], [10]. For example, a company that does not manufacture or develop devices in cleanroom environments may still benefit from some of their technicians having an understanding of general cleanroom protocols and procedures for semiconductor manufacturing as they work with others in the field. In addition to leveraging existing collaborations or partnerships with industry, utilizing third parties in identifying new potential industry partners can be a valuable strategy. Some companies may be utilizing an existing shared facility or may be organized around industry trade or business organization, which could facilitate initial outreach to potential partners [1], [11], [12].

Once a particular company has been identified as a potential partner, reaching out to the right person at that company is an important next step. For most projects that involve curriculum development or modification, a subject-matter expert with corresponding expertise in the required knowledge, skills, and abilities is critical. General human resources contacts may be able to provide contact information for relevant subject-matter experts [5], [6], [8], [13].

Potential Partnerships Beyond Industry

Beyond the critical industry partners that are looking to hire trained technicians, additional partners may be able to provide valuable input into and assistance with the project. Existing government-initiated or government-funded centers, such as the Micro Nano Technology Education Center (MNT-EC) [14] or the Support Center for MicroSystems Education (SCME) [15], or industry organizations could provide assistance with gaining access to existing curriculum resources from other institutions. Local community business organizations, such as the Chamber of Commerce, could provide a venue for broader input and assist with outreach or community awareness campaigns [16]. Regional collaboratives assisting with employment data collection or corresponding data analysis could provide long-term employment data and projections that could be leveraged to validate an initial workforce development need and a potential subsequent project expansion [7], [17]. Regional or county workforce development boards or similar local government organizations could support a project in a similar way [18]. Once the initial training curriculum has been developed and implemented, local high school partners can play an important role in continuing efforts to create awareness and in outreach and recruitment efforts.

Collaborating and Interacting with Partners

As is the case with any partnership or collaborative effort, all parties involved will need to see value and gain at least some benefit for it to be sustainable long-term. While some activities may be more valuable to some partners than others, all partners will likely want to see ongoing value from participating in the project or be able to link activities to the objectives supporting the long-term workforce development goals [13], [19].

Most technician education projects will include some level of curriculum development or modification that requires industry input. Gathering critical industry input in an efficient manner and implementing it into the curriculum, as appropriate and necessary, can aid in supporting the common workforce development vision among the project partners. Regular check-ins with industry partners on their desired level of involvement in potential activities beyond curriculum development and their possible time commitment to the project can further support the collaborative nature of the interaction [13]. It is important to keep in mind that different

partners may come with different expectations or different constraints to the partnership, which may impact their level of involvement. The size of the company, the number of support staff or their availability, or additional constraints could impact overall time commitment or the availability for certain additional activities, such as tours or networking events [13].

Effective and efficient collaboration with industry partners is critical for the ongoing success of the project. One common model for facilitating regular interaction between faculty and industry representatives is an Industry Advisory Board (IAB), in which industry representatives and subject-matter experts advise the faculty on the desired learning outcomes and provide additional input into the project, as needed and desired. A variation of this advisory board model is the Business and Industry Leadership Team (BILT), which provides for deeper industry involvement in program leadership [20]. In this co-ownership model, industry members co-lead and co-design the project components and curriculum, potentially leading to stronger faculty-industry relationships and stronger student-industry connections [20], [21].

Common Goals and Challenges

An initial needs assessment carried out by an external evaluator can assist with identifying some of the specific industry needs [3]. This can be particularly helpful with respect to developing common ground for additional training needs, i.e., developing training that serves industry well without being too narrowly focused on a particular company's specific requirements that could otherwise be addressed through initial on-the-job training [10], [22]. Students will ultimately be best served completing a pathway that can lead to jobs with several industry partners rather than being specific to one or a very limited number of companies [3].

In addition to agreeing on and developing curriculum that will serve a sufficiently broad set of industry partners, other common challenges could be around employment growth predictions, community awareness and outreach efforts, and student recruitment avenues.

Results and Discussion

Identifying Potential Industry Partners

The CC-PRIME project evolved out of ongoing interactions between community college and university faculty and staff, and local industry representatives through the Center for Science and Engineering Partnerships [1], [23]. All of the project's initial industry partners are regular users of the NanoFab facility at the University of California Santa Barbara, resulting in regular and ongoing interaction between NanoFab staff and industry representatives [11], [12]. In addition, long-standing collaborative projects between university staff and community college faculty provided for initial conversations around micro nano technology-related job opportunities in the area [23]. It is in these conversations that NanoFab users from industry relayed their need for technicians in micro nano technology and semiconductor-related fields, along with their difficulty in recruiting corresponding talent, both from within as well as from outside of the region [3], [23], [24]. These connections, in turn, enabled initial conversations between industry representatives and faculty around industry's training needs. The project's initial IAB then grew out of industry users of the NanoFab facility, which facilitated finding additional industry partners with a vested interest in aiding in the development of regional technician training. Most of these companies are small- to medium-sized; some have their own cleanroom facility, while others rely exclusively on the NanoFab facility for cleanroom use [1]. Even some of the larger companies with their own cleanroom facilities have connections to researchers and staff at the University of California Santa Barbara who are known to NanoFab staff [11], [12]. While these companies operate in varying fields, they share a common need for cleanroom technicians or micro nano technology/semiconductor technicians. Recruiting these companies via the shared NanoFab facility greatly facilitated the initial engagement, which otherwise would have required personal connections or individual outreach to each company.

Table 1. Main Project Partners and Roles

Project Partner	Acronym	Role/Facility
Santa Barbara City College [2]	SBCC	Community College; Project Lead
University of California, Santa Barbara [25]	UCSB	R1 Research Institution; Project Subawardee
NanoFabrication Facility [12]	NanoFab	UCSB Research and Industry (Shared Use) Cleanroom Facility; Technical Project Staff

Potential Partnerships Beyond Industry

The initial training that was developed for the CC-PRIME project includes significant hands-on training time in a cleanroom, thus requiring access to a facility that most community colleges do not have. While the NanoFab facility at the nearby University of California Santa Barbara campus was instrumental in identifying industry partners, it is exclusively used by university researchers and industry, and is not available for instructional use beyond tours [11]. With the aid of NanoFab staff and the Center for Science and Engineering Partnerships, two additional cleanroom facilities at the university were identified that can be utilized for instructional purposes [26], [27]. Facility and staff availability for training then determined the most suitable facility to be at the California NanoSystems Institute located at the university. This model of building instructional facility access time into projects that require training in a specific facility that is not available at a community college can be effectively implemented by utilizing appropriate facilities at nearby 4-year institutions [1], [23].

In developing and implementing an Advanced Technological Education (ATE) project, the greater ATE community can be an incredibly valuable resource. Existing ATE centers can be an excellent resource for connecting to existing programs in similar fields, sharing best practices, accessing previously developed curricula, and networking. The Support Center for MicroSystems Education (SCME) at the University of New Mexico was instrumental in initiating the CC-PRIME project by sharing existing curricula and best practices and providing training for project staff and faculty [15]. Additional curriculum and best practices resources were provided by the Nanotechnology Applications and Career Knowledge Center (NACK) at Pennsylvania State University [28]. The Micro Nano Technology Education Center (MNT-EC) at Pasadena City College provided valuable Knowledge, Skills, and Abilities resources, as well as faculty professional development and networking opportunities [14], [22]. Being able to take advantage of the resources available in the greater ATE community through these national and resource centers facilitated initial project development and implementation in significant ways [1].

The National Institute of Innovations in Technology served as another resource with respect to assessing the project's KSAs [22]. Its National Talent Hub portal enabled us to link course learning outcomes to required skills listed in local employers' job postings [10]. This information is then utilized to identify potential curriculum adjustments for current or additional training pathways.

Local business and community partners can provide additional benefits to a project targeting a new workforce development pipeline in the region. A local Chamber of Commerce can serve as a hub to connect to additional companies with similar workforce needs and assist with networking, community awareness, and outreach events. Joining the Santa Barbara South Coast Chamber of Commerce Tech Roundtable enabled project leads to network with potential additional industry partners, take advantage of marketing resources to improve visibility and community awareness, as well as pursue additional collaborative funding opportunities for scaling efforts [16].

Similarly, a Chamber of Commerce, a Workforce Development Board, or a related local or regional entity can assist with visibility, awareness, and outreach efforts, also connecting to additional community partners. For CC-PRIME, the Santa Barbara County Workforce Development Board allowed us to make connections to local community organizations working with non-traditional and re-entry students potentially interested in technician job opportunities in the micro nano technology sector [18]. Further support for scaling and pursuing associated funding efforts can also be obtained through a Workforce Development Board.

Once the initial course offerings are in place, ongoing student recruitment into the program may become more and more important. Depending on the type of course offerings and whether or not they are part of an existing pathway, forging new or growing existing relationships with local high schools can have a positive influence on student recruitment and pathway development, as well as overall visibility and outreach efforts. Depending on the local educational environment, including potentially existing collaborative agreements with school districts, availability of instructors and necessary facilities or equipment, one might be able to explore offering some career technical education courses as dual enrollment courses at local high schools.

Table 2. Additional Resource Partners and Roles

Resource Partner	Acronym/Location	Role
Center for Science and Engineering Partnerships [23]	CSEP University of California Santa Barbara	Collaborative Hub for Science/Engineering Education Projects
Education and Industry Working Partners Project [13]	WPP Bellevue College	National ATE Project
Micro Nano Technology Education Center [14]	MNT-EC Pasadena City College	ATE Center
Nanotechnology Applications and Career Knowledge Center [28]	NACK Pennsylvania State University	ATE Resource Center
National Talent Hub [10]	NTH National Institute for Innovation and Technology	Job Portal and Analytics Provider
Santa Barbara County Workforce Development Board [18]	County of Santa Barbara	Local County Business Services Provider
Santa Barbara South Coast Chamber of Commerce [16]	Cities of Carpinteria, Goleta, and Santa Barbara	Local Business Organization Network
Support Center for MicroSystems Education [15]	SCME University of New Mexico	ATE Resource Center

Collaborating and Interacting with Partners

For the development of the initial cleanroom training boot camp at SBCC, we followed an IAB model to work with our industry partners, mainly to align better with their available time and personnel resources and desired level of involvement than what would have been required for following a BILT model [20], [21]. Regular meetings with IAB members at least once per semester, with additional follow-up meetings in smaller groups or one-on-one, as needed, have proven to be important, especially in the initial project phase [13]. Facilitating the initial connections between industry and faculty and keeping IAB members in the loop on the project's progress and the implementation of their input was integral to having industry partners continue

to support the project [3]. The generated buy-in then allowed for additional collaboration and interaction, such as networking opportunities for faculty and students, industry facility tours, and industry participation in outreach and community events, such as the High Tech Pavillion at SBCC's Science Discovery Day. Some of our IAB members have been very active in participating in additional activities, while others have not, for a variety of reasons, such as other work demands, limited support staff availability, timing constraints, etc. Other industry partners, on the other hand, have exclusively participated in networking and outreach events or tours without actively participating in the IAB [29], [30]. We have found that engaging different industry partners at different levels, trying to meet their specific needs, and working with their constraints can result in different yet valuable and ongoing relationships that ultimately serve both partners, as well as the students and the community. Resources from the Education and Industry Working Partners project at Bellevue College have proven to be very valuable in developing and adapting these connections with industry. The Working Partners project's workshops and partnership models toolkits can be utilized to successfully frame some of this work [8], [13], [19], [31]. The recently developed Working Partners rubric can assist in gaining clarity on desired levels of industry involvement and in assessing the ongoing engagement appropriately [13], [32].

In addition to the Working Partners models and resources, our external evaluator's initial needs assessment with industry partners provided valuable insight, not only into their employment and associated training/ curriculum needs but also into their desired level of participation in the project [3], [19].

Common Goals and Challenges

The initial needs assessment identified significant overlap in technician training needs for the various industry partners, as well as common challenges with regard to hiring technicians [3]. Technician-level training did not exist locally prior to the development of the initial cleanroom training, and recruiting and especially retaining technicians from outside of the area has proven very difficult due to the overall lack of available, affordable housing in the region [7], [17], [24]. Despite the significant overlap in training needs among IAB members, building consensus for an initial training that would serve the local micro nano technology industry broadly without going into training on specific instrumentation desired by one or very few companies proved challenging. Being able to draw from existing resources with long-standing track records of successfully training students in broadly applicable concepts and curriculum, such as the available SCME curriculum, ultimately aided in generating the necessary buy-in and consensus among IAB members [3], [15], [22]. The external evaluator’s industry needs assessment also aided in highlighting the commonalities among industry partners’ training needs [3]. As additional training modules and courses are being developed, some of the more specific training asks can be explored further.

In cases where industry partners are primarily small, start-up, or newly established companies, awareness in the local community about these companies and associated job opportunities can be lacking. Santa Barbara County is such an example. It hosts more than 45 companies, most of which are small to medium-sized and which operate in the micro nano technology and semiconductor application space [1], [7], [9], [33], [34]. At the same time, some of the larger companies that operate in the defense application sector have been in the area for a long time and are relatively well-known in the community; most of the smaller ones that are relatively new are not. There is a significant lack of awareness in the community about these companies that operate in the integrated photonics, infrared, microelectronics, microfluidics, biotechnology, and medical imaging fields, and the job opportunities, especially at the technician level, that are available [1], [9]. As additional training and student pathways are developed, this lack of awareness is likely to lead to recruitment challenges, especially in the early stages of program roll-out. Being able to draw from industry partners who are willing and able to engage in networking events and facility tours for faculty and students, as well as larger outreach events to the community, has helped with increasing awareness about these companies and associated job and career opportunities [29], [30]. Collaborating with community partners, such as the local Chamber of Commerce and the County Workforce Development Board, has provided additional opportunities to engage in community outreach and awareness campaigns and events [16], [18], [35]. Once additional student pathways and training are implemented, the next step is to take these outreach and awareness efforts to the local high schools, again drawing on industry partners to assist.

Additional or ongoing funding may be necessary to carry out some of these outreach and awareness efforts, along with additional curriculum and student pathway development, as well as potentially emerging equipment needs. Being able to show strong industry support is critical for additional funding proposals to address some of these challenges. In addition to our strong industry partner support for obtaining subsequent funding,

some of the mentioned additional partners, such as the Workforce Development Board and the Chamber of Commerce, have proven to be valuable partners in pursuing subsequent external funding opportunities, especially for outreach, networking, and marketing efforts [16], [18]. These entities have also been able to assist with gathering broader regional and state-wide data on future employment trends in related fields to further guide the conversations around expanding technician-level training efforts [7], [17].

Conclusion

In working with industry and other partners on developing and expanding this initial micro nano technology training, several important key points have emerged:

Leveraging and Expanding Existing Partnerships

Existing collaborations through the Center for Science and Engineering Partnerships facilitated the initial discussions to envision a workforce development effort such as the CC-PRIME program. The critical piece, however, that enabled us to implement the initial project with significant and broad industry buy-in and support was the connection to the shared NanoFab facility [1], [11], [12], [27]. Being able to draw on NanoFab staff expertise and direct connections to facility industry users had a significant positive impact on developing initial industry connections and getting the project started. It is clear that it would have taken much longer to develop these industry connections and relationships without access to a shared-use facility and its existing staff connections [1], [29], [30].

Being able to connect to an existing shared use facility, potentially located at a four-year institution, can aid significantly in making initial industry connections or expanding to additional ones.

Establishing and Engaging Partnerships beyond Industry

Beyond the critically necessary industry partners, valuable additional collaborators can be both at the local/regional as well as national levels. Existing national ATE Centers or long-standing resource/support centers can provide valuable curriculum and KSA resources, networking opportunities, and information about best practices. For our initial project, the Support Center for MicroSystems Education (SCME), the Micro Nano Technology Education Center (MNT-EC), and the Nanotechnology Applications and Career Knowledge Center (NACK) all provided extremely valuable information and resources, including curriculum and KSAs, to develop and implement the initial project phases [1], [14], [15], [22], [28].

Another national resource that is available through the NSF ATE community is the Education and Industry Working Partners project, which provides various tools, resources, and workshops around industry involvement and engagement efforts [8], [13], [19], [31]. The resources and guidelines available through the Working Partners project, along with some of its workshops, have been particularly helpful in assessing, documenting, and expanding our collaborative efforts with industry [32].

At the local and regional level, the Chamber of Commerce and the Workforce Development Board have been able to assist with visibility and marketing, outreach and recruitment efforts, along with making connections to additional industry partners, all of which have benefited these workforce development efforts in the community [16], [18].

Utilizing and adapting existing curriculum resources and known best practices is often a successful strategy when developing new training pathways. The existing ATE Centers have been shown to serve as excellent hubs for enabling these types of connections and providing corresponding resources. Existing city or county entities dedicated to overarching workforce development efforts can provide additional support at the local level, focused on increasing awareness and outreach.

Ongoing Partner Involvement

Regular interaction and communication with key partners are important for ongoing engagement [31]. Regardless of whether an IAB model or BILT model is followed, all partners in the collaborative effort will need to see ongoing value in their contributions, with some of their views getting incorporated into the project, if feasible and agreed upon [13], [20], [21]. The specific commitment level may vary from one partner to the next but should be aligned with the agreed-upon expectations and the project goals [13]. We have found an initial needs assessment, e.g., through an external evaluator, to not only aid in assessing training needs but also in developing a common framework for project participation from each partner [3]. In addition,

the Education and Industry Working Partners project has valuable tools, resources, and rubrics available for engaging industry partners, assessing and improving the partnership [8], [13], [19], [31], [32]. These resources and tools have had a significant positive impact on our ability to gauge and assess industry engagement with the ultimate goal of continuing the partnership long-term and sustainably.

Future Directions

Being able to leverage connections through an existing shared-use facility with industry, as well as curriculum, tools, and resources from national ATE Centers, have been critically important in being able to launch the initial micro nano technology cleanroom training and have reduced the planning phase significantly. Current efforts are in progress to expand this training to include more in-depth semiconductor fabrication technician training modules, in order to provide more robust pathways for local students to obtain technician jobs with our local industry partners. Resources and tools from ATE-funded projects, such as the SCME, NACK, and the Working Partners Project, are aiding in these efforts [13], [15], [28]. Ongoing collaborations with regional entities focused on workforce development continue to assist in local outreach campaigns to increase community awareness, all in an effort to broaden the micro nanotechnology training opportunities and corresponding student educational pathways in the region [16], [18], [35].

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