Although the economy in the tristate Appalachia region of southwestern Pennsylvania, northern West Virginia, and eastern Ohio has long included the production and extraction of energy from fossil and renewable sources, natural gas production in the region has grown significantly since 2008 because of the use of hydraulic fracturing and horizontal drilling to extract natural gas from the Marcellus and Utica Shales. As of 2018, Appalachian gas accounted for almost half of total U.S. dry natural gas production (U.S. Energy Information Administration, 2018).

This growth in energy production has led to an increase in demand for workers who are proficient in STEM. In addition, employers in the region are searching for workers with cross-cutting skills, such as problem-solving and teamwork, and those who demonstrate skills hybridization,

**KEY FINDINGS**

- Appalachia Partnership Initiative (API) programs evolved over time to better support awareness, skills development, professional development, and industry engagement through K–12 science, technology, engineering, and mathematics (STEM) education and STEM workforce development programs to educate and train adult workers.

- API programs were heavily represented in Pennsylvania and West Virginia and lightly represented in Ohio and in rural counties.

- Results for awareness about the API’s programs were mixed.

- K–12 STEM education programs included hands-on and project-based instructional models, while workforce programs focused on preparation to enter certain fields through certifications, permits, and associate’s degrees.

- Program administrators reported that industry engagement was critical, but that they encountered challenges in keeping up with evolving industry demands.

- API STEM program administrators reported collaborating with one another, with external funders, with state and national policymakers, and with higher education institutions.
meaning that they have multiple, adaptable skills (Burning Glass Technologies, Council for Adult and Experiential Learning, and Allegheny Conference on Community Development, 2016).

However, a challenge in the region is that, according to many employers, the supply of workers with STEM skills has not kept pace with workforce demand (Burning Glass Technologies, Council for Adult and Experiential Learning, and Allegheny Conference on Community Development, 2016; Gonzalez et al., 2015; Gonzalez et al., 2017), limiting the region’s capacity to benefit from national and global economic advances. This shortage can be attributed to both educational and workforce issues. Regarding education, there is insufficient awareness among families and K–12 educators about STEM-related postsecondary educational and career opportunities for children (Campos Research Strategy, 2014). At the same time, the region has an aging workforce, with an inadequate supply of qualified individuals for middle-skilled occupations (requiring high school and some additional formal training) that require STEM skills (Accenture, Burning Glass Technologies, and Harvard Business School, 2014; Burning Glass Technologies, Council for Adult and Experiential Learning, Allegheny Conference on Community Development, 2016; and Gonzalez et al., 2015).

Recognizing the workforce and education challenges facing the energy and advanced manufacturing industries in the region, the Social Investment Team of the Chevron North American Appalachian Mountain Business Unit launched the API in 2014 and committed to investing $20 million to support K–12 STEM education and STEM workforce development programs to educate and train local adult workers through 2019.

The API consisted of an expanding network of partner organizations from the business, foundation, nonprofit, research, and education sectors and covers 27 counties in Pennsylvania, West Virginia, and Ohio (see Figure 1). In addition to Chevron Corporation, founding leaders included the Allegheny Conference on Community Development and the Claude Worthington Benedum Foundation. The Grable Foundation and Catalyst Connection joined, respectively, in 2016 and 2017. Throughout the five years of API, leaders made investments in K–12 STEM education activities and workforce development projects in energy and advanced manufacturing and engaged in policy discussions and initiatives to catalyze the community to support a skilled talent pool that could become employed in the energy and advanced manufacturing industries. The RAND Corporation served as the external research and analysis lead for API.

The API’s vision is to promote “a sustainable regional energy and manufacturing education and employment ecosystem that supports the region’s broader economic development” (RAND Corporation, undated). It does this by investing in innovative and strategically selected K–12 STEM educational opportunities and workforce development programs across the 27 counties shown in Figure 1. In addition, the API supports community-catalyst efforts that build relationships among the region’s corporate, nonprofit, government, and community leaders.

Figure 2 shows the overall API strategic framework, developed by API leaders with facilitation from RAND in 2015. The framework maps the types of programs to fund, desired outputs and outcomes, and community-wide long-term outcomes and impacts. Moving from left to right in the figure, various resources (inputs) are invested in the three types of program activities.1 These programs are expected to produce various direct outputs, including awareness, skills acquisition, professional development, industry engagement, community involvement, and networks for change. These outputs are then expected to lead to the listed

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### Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>API</td>
<td>Appalachia Partnership Initiative</td>
</tr>
<tr>
<td>CMP</td>
<td>Children’s Museum of Pittsburgh</td>
</tr>
<tr>
<td>CSC</td>
<td>Carnegie Science Center</td>
</tr>
<tr>
<td>IU1</td>
<td>Intermediate Unit 1</td>
</tr>
<tr>
<td>PCT</td>
<td>Pennsylvania College of Technology</td>
</tr>
<tr>
<td>PLTW</td>
<td>Project Lead the Way</td>
</tr>
<tr>
<td>STEM</td>
<td>science, technology, engineering, and mathematics</td>
</tr>
<tr>
<td>TEAM</td>
<td>Tri-State Energy and Advanced Manufacturing</td>
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1 These programs are expected to produce various direct outputs, including awareness, skills acquisition, professional development, industry engagement, community involvement, and networks for change.
Over the longer term, the program-related outcomes are intended to produce broader community outcomes in terms of improved STEM educational outcomes, increased employment in energy and manufacturing, and an active and sustainably funded community of workforce policy advocates.

Over the course of the API, we monitored 24 programs administered by 11 grantees: 11 programs administered by five K–12 STEM grantees (2014–2019), seven programs administered by four workforce development grantees (2014–2018), and six programs administered by two grantees that offered both K–12 STEM and workforce development programming, which we refer to as hybrid grantees (2014–2019). API adjusted its grantmaking throughout the five years so that, by December 2019, API was actively funding seven grantees: Project Lead the Way (PLTW), Children’s Museum of Pittsburgh (CMP), Intermediate Unit 1 (IU1), and Education Alliance, Catalyst Connection, Central Greene School District, and the TEAM Consortium. In some cases (e.g.,
ShaleNET, Energy Innovation Center, Southwest Training Services) grantees and programming had ended. In other cases (e.g., Carnegie Science Center), API and the grantee decided to move in other directions and thus funding ended. Grantees and programs are listed in Figure 3; more information about the grantees and programs is available in Table A in the appendix.

**Study Objectives and Approach**

We conducted an assessment of the API’s progress toward its vision and goals, with interim assessments:

- The first interim assessment analyzed the beginning stage of the API from October 2014 through December 2016 across all of its endeavors: K–12 STEM, workforce development, and catalyzing the community (see Gonzalez, Culbertson, and Nanda, 2017). An associated technical appendix is available (see Culbertson, Gonzalez, and Nanda, 2017).
- The second interim assessment reviewed the API’s progress from October 2014 through December 2017 toward its vision for K–12 STEM activities and initiatives related to catalyzing the community (see Gonzalez, Culbertson, and Nanda, 2019).
- The third assessment focused on API’s progress in meeting its goals and vision for workforce development activities and community catalyst initiatives from October
This final report summarizes our analysis of the impact of API investments in K–12 STEM education, energy and advanced manufacturing workforce development, and community building over the five-year period from October 2014 through December 2019.

This report considers six questions. We address the first five questions with a summary of findings from the previous three reports, some additional analyses, and summative conclusions. The sixth question brings together our conclusions from the multiple years of this study and introduces research ideas that could contribute to the body of knowledge on K–12 STEM education, workforce development, and portfolio assessments in the region.

- **Strategic alignment**: How did the API’s programs and activities evolve and adapt to meet the API’s vision and strategy?
- **Geographic scope and beneficiaries**: What was the geographic scope of API programs and which beneficiaries did the programs reach?
- **Reported impact**: What impacts did interviewees’ report the portfolio having on key outputs: awareness, skills acquisition, professional development, and industry engagement?
- **Community catalyst**: In what ways were API leaders and programs connected with each other and with other stakeholders in the region?
- **Sustainability**: To what extent can API-funded programs continue into the future, with or without continued API funding?
- **Implications from the API’s experience**: What can other regions or consortia of funders in the United States learn from the experience of API? What types of future research are needed to continue to inform the...
region on how to grow a talent pool in STEM skills and meet the demands of the STEM workplace?

To answer these questions, we relied on the following data sources (details on data collection, methodologies, and analytic approach are available in Culbertson, Gonzalez, and Nanda, 2017):

**Interviews and site visits.** In July and August of each year of the study (2015, 2016, 2017, 2018, and 2019), we interviewed API program administrators, inquiring about program activities and mission, beneficiaries, facilitators and barriers to implementation, sustainability, funding or in-kind support, and reported effectiveness. We also visited program sites in 2015 and 2018. Over the five years of the evaluation, we engaged in ongoing meetings with API leadership to discuss strategy and progress. We also surveyed API leaders to inquire about the role each leader has taken in serving as a community catalyst, the nature of their community relationships, and connections. We analyzed interview data by organizing program administrators’ responses according to the research questions and then aggregating cross-program similarities and differences.

**Quantitative indicators.** From August 2015 to December 2019, program administrators submitted to us quantitative indicators on number and type of beneficiaries, networks, professional development, and community and awareness activities. The data covered August 2014 through December 2019.

**Network analysis diagrams.** Using the quantitative indicators and interview data, we produced network-analysis diagrams to analyze relationships among API programs, funders, and partners.

**Literature review.** To inform our understanding of the extent to which programs were incorporating evidence-based practices in their programming, we conducted a literature review of select topics, including museum-based informal education; activity-, problem-, and project-based instructional approaches; approaches to increase awareness for STEM career pathways; sector-based career pathways; promising models in workforce development programs; network analysis in nonprofit settings; and related policies and activities in K–12 STEM education and workforce development.

There are three important limitations to this assessment:

- This report evaluates the API portfolio, not individual programs. It focuses on how programs collectively promote the API’s goals and identifies where gaps exist.
- This analysis incorporates data from multiple sources, some of which were self-reported or incomplete because of the newness of the API programs and their data-collection efforts.
- We report our analyses of the outputs as itemized in the API Strategic Framework (Figure 2). Although the API has been in existence for five years at the time of this study, and thus one would expect that analyses could track short- and medium-term outcomes, we were only able to collect data from the grantees’ reports on their outputs. Ideally, other research efforts should be able to track changes through time on the short- and medium-term outcomes, which would entail a more comprehensive data collection effort.

**Strategic Alignment**

Activities varied across K–12 STEM programs and included implementation of structured STEM curriculums, project-based and collaborative learning, making, digital learning and fabrication, video contests, career exploration with local employers, and professional development. Similarly, workforce development programs spanned safety training, specialized training for dislocated workers, and technical training for careers in the oil and natural gas industry within the API region. The two hybrid programs, Catalyst Connections and Natural Resources Course at Central Greene School District, strived to bridge the gap between K–12 STEM education and careers in energy and advanced manufacturing.

Our interviews with program administrators revealed that a number of programs expanded both in size and number of partnerships since receiving API sponsorship and have evolved to meet perceived
needs. K–12 STEM and hybrid programs grew in size, expanded geographically, added programming to address special needs students, expanded across grade levels, and added programming that involved the region’s industries. Workforce development and hybrid programs were regularly engaged with local employers to adapt their curriculum and increasingly undertook activities to remain current on industry demands. Programs added or adapted training opportunities in plastics, additive manufacturing, oil and gas industry–related occupations, and industry-specific safety standards.

The API also made a strategic shift in its workforce development efforts in 2018: As API sponsorship of several programs came to an end, API leaders and other partners established the Tri-State Energy and Advanced Manufacturing (TEAM) Consortium with the primary goals of coordinating workforce development activities within the region, strengthening industry engagement, and gathering data to develop common career pathways for middle-skill positions in energy and advanced manufacturing. TEAM Consortium members include community colleges, college associations, Manufacturing Extension Partnerships, and workforce development boards within the Appalachian region. Although API funding for workforce development programs previously was used to support individual programs, the funding to the TEAM Consortium was specifically used for coordination of activities across community colleges with industry leaders.

Detailed information about the evolution of each program through the duration of the API funding is available in the previous reports in this series and summarized in Table A in the appendix.

Geographic Scope and Beneficiaries

We now document the intended beneficiaries of API-sponsored K–12 STEM, hybrid, and workforce development programs and the number of K–12 students and working-age adults (age 18–64) who participated in the programs over time; and the location of API-sponsored programs across its 27-county API footprint. We relied on information from interviews with program administrators and the quantitative indicators administrators supplied.

API leadership recognized that its programs alone could not feasibly reach all individuals across the entire 27-county footprint. Thus, the snapshot of beneficiaries reported here—and in the other reports in this series—was intended to inform API leaders on whether sponsored programs reached intended subgroup populations and, if not, which specific regions or populations had gaps in programming.

API-Sponsored Programs Were Concentrated in Pennsylvania and West Virginia

The previous reports in this series illustrated the geographic reach of API K–12 STEM and workforce development programs in 2014, K–12 STEM education programs in 2017, and workforce development programs in 2018. In each of the reports, we reported that API programs were available in all 27 API counties. Most API-funded K–12 STEM programs were offered in southwestern Pennsylvania, with a concentration of programs in Allegheny County (eight out of nine programs), where there was also the largest number of public schools, school-age children (age 3–17), and working-age adults (age 18–64). All API workforce development programs were available in counties in northern West Virginia and in Allegheny County. There were few API-sponsored programs offered in Ohio counties (two K–12 STEM programs [Carnegie Science Center’s Mobile Fab Lab and PLTW] and two workforce development programs [ShaleNET and Energy Safety Passport]). These findings have remained consistent throughout the series of reports: There had not been much of a change in
the geographic reach of the API K–12 STEM and workforce development programs between 2014 and 2019.

API-Sponsored Programs Targeted a Wide Range of Students and Adults

API leaders allowed flexibility in which age ranges or types of participants sponsored programs could target. Grantees aimed to reach a wide range of potential beneficiaries—from elementary school students to dislocated coal miners (see Table B in the appendix for a list of targeted beneficiaries of grantees). Figures 4–6 illustrate the number of participants that the API-sponsored programs reached through time. Each year is a snapshot of participation, so it may include individuals who participated in previous years or who were new to a program; many programs were not able to distinguish between these two types of participants in their data. Furthermore, some programs were not able to provide data for each period.2

Figures 4 illustrates that K–12 STEM program administrators reported that a peak of about 40,000 students under the age of 18 were reached from August 2015 through July 2017. Since then, the number of students reached dropped to about 26,000 in year 4 (August 2017–July 2018) and about 11,000 in year 5 (August 2018–July 2019). The reduction in the number of students reached by programs was primarily because API ended its sponsorship of the Carnegie Science Center (CSC) at the end of 2017.

Figure 5 illustrates the number of students under age 18 years that were reached by the hybrid programs. Here, we see that administrators reported a peak of 1,148 students participated in programs in year 5 (August 2018–July 2019). The number of participants was not stable from year to year but had grown since 2014. Both hybrid programs’ administrators reported that in years 3, 4, and 5 they had increased the types of activities offered by their programs and had increased outreach to attract more participants to their programs.

K–12 STEM and the hybrid program administrators reported that, on average, 48 percent of K–12 students reached by their programs were low income, 47 percent were girls, and 42 percent attended school in rural communities.

### FIGURE 4
Total Number of Students (Under Age 18) Reached by API K–12 STEM Programs (2014–2019)

<table>
<thead>
<tr>
<th>Time period</th>
<th>Number of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1: October 2014–July 2015</td>
<td>23,969</td>
</tr>
<tr>
<td>Year 2: August 2015–July 2016</td>
<td>39,876</td>
</tr>
<tr>
<td>Year 3: August 2016–July 2017</td>
<td>39,284</td>
</tr>
<tr>
<td>Year 4: August 2017–July 2018</td>
<td>26,208</td>
</tr>
<tr>
<td>Year 5: August 2018–July 2019</td>
<td>11,306</td>
</tr>
<tr>
<td>Final Quarter: August 2019–December 2019</td>
<td>1,387</td>
</tr>
</tbody>
</table>

SOURCE: Quantitative indicators provided by grantee administrators (August 2015–December 2019).
NOTE: These counts may include repeat students, so we were not able to determine the overall number of individual students participating in the programs.
Figure 6 illustrates an increase in the number of working-age adults who participated in the workforce development programs: increasing from 77 and 86 in years 1 and 2 to 734 in year 4.

While it is difficult to pinpoint the exact number of individuals touched by these programs, these figures suggest that, between 2014 and 2019, hybrid and workforce development programs reached more beneficiaries from one year to the next; but the K–12 STEM programs reached fewer (after peaking in year 2).

Reported Impacts in Key Strategic Areas

In this section, we summarize our analysis of the K–12 STEM, hybrid, and workforce development programs’ reported impacts in specific strategic areas: awareness, skills acquisition, professional development, industry engagement, and skills alignment.

Awareness

Awareness is a key component within API-sponsored programs, as illustrated in Figure 1. As noted in the previous reports in this series, one theory underlying API investments is that, if students, parents, educators, business leaders, and workers understand the value of STEM skills and knowledge and are aware of STEM career pathways and training and development opportunities, then more students will pursue STEM career pathways and more workers will use the training programs.

At the beginning of API investments, many of the program administrators interviewed described the need for better awareness of opportunities in manufacturing and energy. Indeed, studies (e.g., Campos Research Strategy, 2014) have found that students, parents, and others have negative perceptions of jobs in energy and advanced manufacturing or are unaware of career opportunities in these fields. Several interviewees believed that historical experience in the Greater Pittsburgh region had contributed to negative perceptions, including the collapse of the steel industry in the 1970s or the oil and gas industry
downturn from 2016 to 2018. Possibly because of lack of awareness, several API workforce development and hybrid programs struggled with not having enough students, and this also affected participation in skills development programs for adults.

Interviewees described multiple approaches toward improving awareness and believed that they had improved awareness on a limited scale. API K–12 STEM awareness activities included engaging children in STEM activities and “making” in museum or maker-space settings to promote excitement about STEM, hosting public events meant to inform or engage students in STEM and related career opportunities, bringing employers into classrooms, helping students make videos, engaging students in pre-apprenticeships and other site visits, asking teachers to focus on STEM careers in the classroom, and applying for additional grants to target awareness. One program aimed to shift the narrative about opportunities to use manufacturing to help people, for example, by contributing to the medical industry. Another program aimed to shift the narrative with parents, communicating that manufacturing is not a “dead-end job.” One workforce development program described how advertising and providing scholarships for students to attend their program had served as an awareness-building tool.

Public awards and events also help programs gain visibility. Altogether, API programs received 42 public awards and reached 91,065 individuals through their public events. Some example events include the CMP’s Maker Faires, IU1’s mobile Fab Lab outreach, science fairs, and career exploration and job fair events.

**Skills Acquisition**

The acquisition of skills necessary for success in the energy or manufacturing sector is important for supporting students and workers in pursuing STEM career pathways. Multiple API programs focused on skills acquisition (viewed here as consistent and repeated teaching of STEM skills, as opposed to a one-time awareness event), aiming to align skills training with industry needs. One program described their mission to “get [students] prepared to enter the field.”
Interviewees reported that their programs took multiple approaches to skills acquisition. Several programs developed and implemented curricula in STEM at the elementary and high school level. API has also funded several workforce development efforts to support high school students in gaining the technical qualifications and professional experience needed for careers in the oil and gas industry, including industry-based certifications, on-site training with employers, and apprenticeships for high school students.

From 2016 to 2018, API also funded separate oil and natural gas industry workforce development programs at four community and technical colleges in a consortium called ShaleNet: Pennsylvania College of Technology (PCT), Pierpont Community and Technical College, Stark State College, and Westmoreland County Community College. API funding for ShaleNET provided each college with support for scholarships, professional and curriculum development, equipment purchasing, and other unique program components. The colleges offered certifications, permits, specific courses, and associate’s degrees. Specific skills included welding, machining, engineering, drafting, automation, robotics, and plastics manufacturing.

There was also an evolving recognition, among both program administrators and API leaders, of the need to ensure that the STEM curriculum also includes an emphasis on workplace competencies, or “soft” skills, such as critical thinking, problem solving, or being able to follow instructions and work in a team. Indeed, studies in the region have found that employers note that they have difficulty hiring because the talent pool lacks workplace competencies (Gonzalez et al., 2019). One program administrator believed that soft skills should be taught in an integrated way with technical skills, noting, “21st-century soft skills don’t resonate until they are on a team and do a project.” Table C in the appendix lists the various skills acquisition models employed by grantees.

Professional Development

As reported to us by grantees, API programs provided professional development resources for educators involved in their programs. The bulk of this activity occurred in the 2017–2018 academic year, during which program administrators reported that their professional development activities touched 1,312 K–12 teachers. There is a drop-off in the number of teachers reached in subsequent years because many programs either stopped being funded by the API (e.g., CSC) or programs trained teachers primarily in the start-up phases of their programming. Figure 7 illustrates the number of teachers reached by the programs’ professional development opportunities.

Program content ranged across programs from teaching methods (e.g., project-based learning, blended learning) to subject-specific skills (e.g., making, electronics, digital fabrication, safety, industry-based certifications). Training programs offered by API programs varied widely in training hours, from several hours to a full week (for more information, see Gonzalez, Culbertson, and Nanda, 2019).

Administrators described several key challenges in offering teacher professional development. These included insufficient time out of the classroom for training, competition for teachers’ time for professional development among multiple possible training opportunities in the region, winter weather conditions that made schedules unpredictable, varying state certification and training recognition...
regulations, geographic spread of teachers, and turnover among trained teachers leading to the need to repeat the same professional development with new teachers. Approaches to addressing these challenges included providing shortened training options, offering training at schools to make the training more convenient for teachers, and ensuring that training included a state-recognized certificate.

Industry Engagement and Skills Alignment

Industry engagement is important to ensure that K–12 STEM education and workforce training programs are covering appropriate subject matter and aligned with employers’ needs. API workforce development programs and API leaders in our interviews described efforts to regularly communicate with local employers to align their curriculum, activities, and training with evolving industry demands. They also relied on employers to provide on-site training to program participants at employment locations and donate equipment. Programs also aimed to align their offerings with their understanding of industry demand for skills and skills shortages, based on their interactions with employers.

Despite these activities, program administrators described ongoing challenges in keeping up with evolving industry demands. In some cases, fluctuating industry demand for workers with particular skills made planning skills-training programs and attracting participants difficult. Several program administrators believed that training could be adapted for employers if structures were in place to understand employer needs: “Even if an industry changes, we can pivot and do new opportunities. We were really successful at pivoting.” Some programs evolved into attempts to increase engagement with industry leaders. For example, the TEAM Consortium, which supports coordination of curricula across participating colleges, set industry engagement as a key future goal (other examples are listed in Table A in the appendix).

API leaders emphasized the need to increase engagement with employers, starting with the Chevron Center for Corporate Responsibility, which has more than 100 companies participating in it as one method to improve these companies’ engagement with one another and to prompt coordination in social investments.
Community Catalyst

Recognizing that the set of API programs, on their own, would not be sufficiently at scale to achieve the API’s next-generation vision illustrated in Figure 2, API leaders aimed to mobilize a community of education, workforce, private-sector, foundation, government, and nonprofit leaders to work toward similar goals as part of its community catalyst effort. The API’s vision was for its leadership and programs to pursue four outputs: (1) contributions of resources, (2) policy advocacy to improve K–12 STEM education and workforce development, (3) community involvement among educators, businesses, media, and others, and (4) networks with industry associations and government agencies. To inform our analysis of the ways in which the API leaders and programs were connected with other stakeholders in the region, we conducted network analyses based on information provided by API leaders and program administrators. API leaders and other stakeholders in the region can use the findings from this analysis to consider how they can most effectively manage their individual and collective relationships to achieve the community catalyst goals.3

In this section, we illustrate the connections among various entities associated with API as of December 2019 (we were not able to examine the depth or strength of those ties). Looking across the figures, we see that API-sponsored programs collaborated with one another, with external funders and other organizations, with state and national policymakers, and with higher education institutions. At the same time, interviewees reported a need for a well-defined policy agenda and better coordination of API funding and activities across state boundaries within the API region.

API Program Connections with API Leaders and Other API Programs

Figure 8 depicts connections among API leaders and the seven API grantees that were funded by API as of December 2019, as reported in data submitted by grantee and program administrators and interviews with program administrators and API leaders (it thus does not include previously funded programs).

The TEAM Consortium and Catalyst Connection maintained connection with the majority of API leaders, including Chevron, Allegheny Conference on Community Development, and Benedum. IU1 seems to have the most central role among STEM programs because of its connection with PLTW, Education Alliance, and Catalyst Connection. IU1 and Catalyst Connection are also a part of the Remake Learning Network (see Figure 9). On one hand, Catalyst Connection could spearhead concerted STEM education and career efforts in the region because of its connections with both STEM and workforce development programs. On the other, CMP and the Natural Resource Course at Greene County seem to be the most disconnected from the network, with their only connection being Chevron. Given the lack of connection between the K–12 STEM programs and other API programs as of December 2019, the continued partnership among STEM programs and with other API programs—now that API has ended—is not certain. However, the API hybrid and workforce development programs seem to be connected with each other through the TEAM Consortium, suggesting that this organization could play a central role in connecting API workforce development initiatives in the future.

Collaboration with External Partners: In-Kind and Financial Contributions from Government, Private, and Nonprofit Partners

As shown in Figures 9 and 10, a variety of external for-profit, nonprofit, and government partners have provided funding and in-kind support to API programs. At the same time, each API program’s network of funders is largely disconnected from the network of funders of other API programs; this pattern is similar to that found in the previous reports in this series (Gonzalez, Culbertson, and Nanda, 2017; Gonzalez, Culbertson, and Nanda, 2019; Gonzalez, Culbertson, and Nanda, 2020). In particular, Catalyst Connection, Education Alliance, and IU1 had multiple additional funders. In the case of in-kind contributions, Catalyst Connection and the TEAM Consortium have the largest networks.
FIGURE 8
Collaborations Among API Programs, December 2019

SOURCE: Quantitative indicators provided by grantee administrators (August 2016–December 2019) and interviews with program administrators (2019).
NOTE: Only the seven grantees that were funded by API in December 2019 are included: four K–12 STEM grantees (Education Alliance, CMP, PLTW, IU1), two hybrid grantees (Catalyst Connection, Natural Resources Course at Central Greene School District), and one workforce development grantee (TEAM Consortium). API funding had ceased for all other grantees by December 2019.
IU1 and Education Alliance had multiple in-kind partners as well. The current set of API programs share a few in-kind contributors: The TEAM Consortium and Catalyst Connection both work with Westmoreland-Fayette Workforce Investment Board and the West Virginia Manufacturers Association.
FIGURE 10
Funding Contributions to API Programs, December 2019

SOURCE: Quantitative indicators provided by grantee administrators (December 2019) and interviews with program administrators (2019).

NOTE: Only the seven grantees that were funded by API in December 2019 are included: four K–12 STEM grantees (Education Alliance, CMP, PLTW, IU1), two hybrid grantees (Catalyst Connection, Natural Resources Course at Central Greene School District), and one workforce development grantee (TEAM Consortium). API funding had ceased for all other grantees by December 2019.
the TEAM Consortium and Greene County both receive support from EQT Corporation, and IU1 and Catalyst Connection continue to be a part of the Remake Learning Network. However, programs do not share any funding sources, suggesting that API programs could splinter into siloed funding and in-kind networks.

API Engagement with Higher Education Institutions

Figure 11 presents the network diagram of API programs’ connections with higher education institutions as of December 2019. API programs have engaged with colleges throughout the course of API, although shifts in emphasis have occurred. The numbers of connections grew over time (see Gonzalez, Culbertson, and Nanda, 2017, for the first set of network diagrams). In early years (2014–2016), the University of Pittsburgh and Carnegie Mellon University were major hubs of collaboration with API programs; in 2017, collaboration shifted instead to emphasize more-local universities and community colleges. The TEAM Consortium has also grown to be a more central player in the API higher education network. Furthermore, unlike previous periods, during which college networks were largely separated by state lines (Gonzalez, Culbertson, and Nanda, 2017), the TEAM Consortium has a more-balanced
distribution of connections with Pennsylvania, Ohio, and West Virginia colleges.

Catalyst Connection and the TEAM Consortium share many university partnerships, including California University of Pennsylvania, Community College of Allegheny County, Community College of Beaver County (leading TEAM), Robert Morris University, Pennsylvania State University, and Westmoreland County Community College (previously part of ShaleNET and API). Additionally, IU1 shares partnerships with California University of Pennsylvania and Pennsylvania State University with Catalyst Connection and TEAM. As expected, TEAM has the largest number of higher education partnerships in the region. Notably, each of the STEM programs is connected to at least one of the TEAM Consortium’s member colleges: In addition to the previously mentioned IU1 connections, CMP and TEAM both partner with the University of Pittsburgh; PLTW and TEAM partner with Stark State College (previously ShaleNET and API); and Education Alliance and TEAM partner with West Virginia University. This indicates that higher education connections might be a potential strategy for API STEM programs to grow collaborative efforts with the region’s workforce development programs.

Involvement in State and National Policy Discussions

API program administrators and leaders reported that they engaged in state and national policy advocacy and discussions, although they expressed that they tended to operate individually. There was no coordinated API policy agenda related to K–12 STEM education or workforce development. For example, Chevron met with state officials in Pennsylvania to build awareness around API efforts and to reduce barriers to implementing K–12 STEM education initiatives, while the Education Alliance program administrators worked with the West Virginia State Department of Education to extend lessons learned from the STEM Network Schools. API program administrators and leaders also participated in national discussions. For example, Catalyst Connection presented on the advanced manufacturing industry’s skills demands at the U.S. House of Representatives’ Manufacturing Caucus. IU1 participated in congressional Maker Faire discussions, which were coordinated by Chevron. Grable spoke at U.S. Department of Education events at the White House. At the same time, in interviews, a number of API leaders discussed the need for more-defined policy priorities, a clearer agenda, and roles for the initiative. Several potential policy priorities described by API leaders included improving awareness and perceptions of STEM careers (both middle and high skilled), guidance counselor and teacher awareness of STEM career paths, and access to job and internship opportunities.

A founding assumption of the API was that the 27-county Greater Pittsburgh Appalachia region could be treated as a single labor shed, with implications that cross-state collaboration within that labor shed could enhance K–12 STEM education and workforce development efforts. Indeed, as highlighted in the previous reports in this series, the API served as a key partner in the regional cross-state STEM ecosystem and engaged in policy advocacy in the early years (2014–2017). For example, API leaders and program administrators held leadership positions in other cross-state K–12 STEM education and workforce development initiatives. In particular, the Chevron Corporation, Benedum Foundation, and Allegheny Conference on Community Development cosponsored the Tri-State Shale Summit meetings in 2015, 2016, and 2017. At the launch of those meetings, in 2015, the governors of the three states signed the Tri-State Regional Cooperation Agreement, which committed the states to “optimize added economic value to the Tri-State Region in a safe and environmentally responsible manner” (Wolf, 2015, p. 2). There has not been similar tri-state coordination of K–12 STEM education activities. However, with time, the advocacy and cross-state role of API lessened. While some API programs and leaders were connected with external partners across the tri-state area, these cross-state collaborations decreased over time, and most collaboration remained within a single state.
Sustainability

A key goal of API leaders was promoting sustainable programs that continue into the future without API funding. Therefore, we analyzed which factors interviewees remarked were likely to facilitate or inhibit API programs’ sustainability (i.e., the extent to which the benefits of an activity are likely to continue into the future and in particular after donor funding has been withdrawn).

Early in the API effort, program administrators identified three factors central to supporting their ability to meet their goals and sustain their programs: (1) government support, (2) industry support, and (3) education support (i.e., the enthusiasm and commitment of teachers, school administrators, and trainers in participating programs because of a perceived need for new STEM approaches). They also noted a number of challenges to sustainability, including (1) misperceptions or lack of awareness about opportunities in STEM careers, (2) weak links between education and STEM careers, (3) lack of teacher qualifications and turnover, (4) inconsistent leadership support at the school or district level for STEM K–12 education programs and (5) industry fluctuations.

Program administrators who reported that they had a financially sustainable model to continue their efforts typically were those with a diverse set of funding and in-kind contribution sources (see Figures 9 and 10). API leaders reported that they required all their grantees to develop a sustainability plan for their grant application or during the initial phases of implementation, including a strategy for building partnerships to ensure continuation of program activities. API program administrators reported a range of funding sources, including private and nonprofit institutions, foundations, federal and state government grants, participation fees, and fundraisers. In-kind contributions from universities, local employers, and other organizations were instrumental in filling in gaps in resources and minimizing maintenance costs; they included support in curriculum development, program consultation, professional development, training, and access to equipment. In contrast, programs with heavy reliance on fewer sources of funding expressed concern over risks to the continuity of their programs, noting that their budgets were often unpredictable because of changing or conflicting national and state priorities.

API funding served as seed funding to attract other funders. Catalyst Connection used API funding to pilot their student video contest; the resulting visibility of the program in turn enabled Catalyst Connection to leverage funding from new partners, including high schools, the state of Pennsylvania, the Pennsylvania Cyber Charter School, local chambers of commerce, and local colleges and universities. Similarly, Chevron funding increased the quality of Westmoreland’s manufacturing courses, which allowed them to receive a designation from the Pennsylvania Department of Labor and Industry as a “group, non-joint sponsor registered apprenticeship,” allowing them to launch an industrial maintenance registered apprenticeship. In the future, Westmoreland plans to establish a machinist registered apprenticeship—these two apprenticeships make their programs more appealing to a larger population, furthering sustainability.

API-sponsored program administrators described other considerations in facilitating financial and programmatic sustainability. For instance, program administrators discussed the importance of allocating funding to foundational elements of their programs to ensure sustainability. The Central Greene School District designated a teacher who was already a long-term staff member within the district for the Natural Resources Course at Central Greene School District and allocated API funding for this training. Westmoreland allocated API funding to purchase equipment for their training, which would have a long-term use. In contrast, the Pennsylvania College of Technology largely allocated funding to scholarships and saw a decline in program enrollment after completing API funding.

Program administrators also mentioned sustainability challenges associated with staff shortages and turnover. As one K–12 STEM program administrator described, “[K–12] schools with turnover really struggled. They could excel one year, and then the next year start at zero.” IU1 leaders stated that committed leadership was helpful in
mitigating turnover impact. They hired a full-time teacher to train other teachers with their specific curricula and equipment, and their program leaders meet at least monthly and sometimes weekly to strategize next steps. Similarly, the Greene County School District primarily invested in one staff member who had been heavily invested in the Natural Resources Course at Central Greene School District, explaining that they preferred to rely on one person who had a demonstrated personal commitment, rather than hiring multiple new educators who did not have that demonstrated commitment and thus might have had a higher chance of leaving. Education Alliance emphasized the implementation of STEM initiatives at the school level for its STEM Network Schools, so that the programs were embedded within the school system in the long term.

Inconsistent program engagement from school leadership, teachers, and students was also a reported challenge of programs’ sustainability, and thus program administrators worked to promote buy-in and engagement by adapting their programming and addressing gaps in school, educator, and employer resources. As one example, several program leaders mentioned difficulty in attracting teachers for their specialized teacher training because of distance to the site, time commitment, competition in the marketplace for other types of teacher training, and lack of perceived value in project-based learning. They addressed this by adapting the length and location of the training and taking steps to increase the name recognition of their programs among teachers, leading to increased teacher attendance (for more examples, see Gonzalez, Culbertson, and Nanda, 2019).

Implications from the API’s Experience

What the API Accomplished

The API set an ambitious, next-generation vision to improve the region’s energy and manufacturing education and employment ecosystem in support of broader economic development, both through investing in particular programs and through catalyzing a community of likeminded stakeholders to work toward these goals.

The initiative met progress in improving awareness, skills acquisition, professional development, and industry engagement and skills alignment. Our analysis found that all of API’s K–12 STEM, hybrid, and workforce development programs addressed awareness about STEM skills, knowledge, and careers in some way. Many, but not all, programs involved skills acquisition, and most of the K–12 STEM efforts included a professional development component. Programs engaged with employers in many ways, ranging from gathering inputs and engaging in regular conversations to setting up advisory groups, bringing employers to speak to students, and providing on-site training at employment locations.

While the initiative had positive strides in the region, our analyses also found that gaps remained. According to interviewees, negative perceptions and lack of awareness of jobs in energy and advanced manufacturing persisted over the course of programs. Program administrators described challenges in keeping up with evolving industry demands. Although API programs existed in all 27 counties comprising the API region, the programs were heavily represented in Pennsylvania and West Virginia and lightly represented in Ohio and in rural counties. Network analyses illustrated that the K–12 STEM grantees were less connected to one another as the hybrid and workforce development grantees. This suggests that once API funding ends, those K–12 STEM grantees might not connect with one another. Interviewees also expressed concerns about the sustainability of funding once API funding ran out, but they did report a number of ways in which they were building funding sustainability.

Implications for the Region and Similar Social Investment Initiatives

API’s experience investing in K–12 STEM education and workforce development initiatives provides lessons for similar initiatives in the Appalachia region and in other state or regional efforts nationally. Key takeaways from this five-year analysis
of API’s efforts are that, to support and sustain regional K–12 STEM education and workforce development systems, it is vital to continue to support programs’ continual evolution, build awareness about STEM education and employment opportunities that also ameliorates negative perceptions of the energy and advanced manufacturing sector, and leverage connections among the private sector, education institutions, and government entities. With these three principles in mind, we offer the following recommendations to any consortium of funders or stakeholders in the Appalachia region or in other regions in the nation with interest in this topic.

Build Awareness of and Excitement About STEM Careers by Exposing K–12 Students to More Hands-On Learning Opportunities

One important way to engage student interest is through hands-on learning, often described in the literature as “inquiry-based,” “project-based,” and “design-based” learning; “tinkering”; or “authentic practice” (Bevan et al., 2015; Charney et al., 2007; Christensen, Knezek, and Tyler-Wood, 2014; Crismond and Adams, 2012; Kanter, 2010; Roth et al., 2009). Hands-on STEM education helps students make the connection between what they learn in the classroom and a future career in STEM (Christensen, Knezek, and Tyler-Wood, 2014). Such experiences can provide access to curricular or learning resources not typically available in the classroom as well as the opportunity to work collaboratively (Braund and Reiss, 2004).

Moreover, informal science education (as opposed to formal classroom learning), such as through museum-based learning, has been found to increase engagement and interest in STEM subjects overall (McMeeking et al., 2016; National Resource Council, 2015). Informal science education programs can serve as models through which to better understand and account for the learning outcomes of participants, especially regarding the connection between interest in STEM and their individual inspiration to learn (McMeeking et al., 2016; Van Eijck and Roth, 2007; National Research Council, 2015). Such out-of-school experiences have also been linked to a decrease in the achievement gap between students of low- and high-income families and might be an avenue for gap reduction for minorities and girls (National Research Council, 2015) and to increased interest in pursuing STEM careers (VanMeter-Adams et al., 2014).

The API, as well as a number of other recent education initiatives both nationally and in the Greater Pittsburgh region, experimented with innovative strategies to build student awareness of and interest in STEM careers and to improve student STEM skills through maker spaces (Blikstein, 2013; Chu et al., 2015; Dougherty, 2012; Halverson and Sheridan, 2014; Holm, 2014; Martin, 2015; Richardson and Haylock, 2012). These types of partnerships among education, employer, and community-based organizations that support K–12 STEM education and maker spaces can help move the needle in embedding novel, informal, and hands-on learning experiences among K–12 students.

Provide On-the-Job Work Experiences for Middle and High School Students

It is vital to reach young people in the region to encourage their exploration in a range of fields and prepare them for the world of work. To do so, the API sponsored a number of K–12 STEM in- and out-of-school hands-on experiences to engage students and increase their awareness about career opportunities. From the perspective of interviewees, these programs were impactful in garnering some attention toward and improving students’ knowledge about career opportunities. However, the API could have also sponsored programs that provided K–12 students with work-based learning experiences.

Programs that provide on-the-job experiences for young people, such as pre-apprenticeships or career magnet high schools, are particularly effective for people most in need of opportunities, especially at-risk youth who could benefit from greater awareness of and connection to career opportunities (Johnson and Spiker, 2018) and can contribute to youth social development and improve mental health outcomes (Buchanan, 2016). Pre-apprenticeships are designed to help individuals gain critical academic skills and receive the combination of industry-based training and classroom instruction needed to move
into an apprenticeship program. Pre-apprenticeships include formalized articulation agreements that allow those who successfully complete the program to enter directly into a registered apprenticeship (Oates, 2012) and can be used by youth or adults. Career magnet high schools integrate field-specific training and curriculum with internship and shadowing opportunities. One interesting aspect of career magnet high schools is that the career theme is typically a vertically integrated industry theme. Instead of a high school centered around jobs that require the same education level, career magnets are oriented around single industries or areas that have numerous educational requirements. For example, the Urban Assembly New York Harbor School in New York City, which started in partnership with the South Street Seaport Museum and the Waterkeeper Alliance, allows students to choose an emphasis in vessel operations, ocean engineering, marine systems technology, professional or scientific diving, advanced marine biology research, marine policy and advocacy, or aquaculture. These focuses would allow students to choose to pursue jobs straight out of high school or to continue with further education. We suggest that these types of work-based learning experiences for middle and high school students be expanded in the region or in other regions across the United States.

Support the Creation of Industry-Driven Public-Private Partnership Models

Industry-driven public-private partnerships—also referred to as sector partnerships or models (Brown, 2018)—are collaboratives among public agencies and the economic stakeholders in a targeted industry, cluster of industries, or occupations. Under the Workforce Innovation and Opportunity Act, local areas are required to create industry and sector partnerships to support state and local areas’ workforce development plans. The partnership is a working group focused on identifying shared goals and needs of the industry in a local area. Members can include representatives from businesses, state or local workforce development boards, higher education, and labor organizations (Spiker, 2019). As of 2017, 29 states (including Ohio and Pennsylvania) had policies that supported the creation or expansion of sector partnership policies. Although these stakeholders must be involved at some point in the partnership, the Workforce Innovation and Opportunity Act definition intentionally leaves control of who, when, and to what extent each partner is engaged up to the local collaborators (Spiker, 2019).

The API is, in part, one such partnership, bringing together multiple businesses, foundations, educational institutions, and other stakeholders to target efforts toward a common goal—in this case, supporting the energy and advanced manufacturing industries. These partnerships can have a number of benefits, including hiring and training efficiency for the employers involved (Brown, 2018), improved understanding of a region’s needs among educators (Woolsey Group, undated), and greater access among trainees and employees to career-advancing training (Conway and Giloth, 2014; Kochan, Finegold, and Osterman, 2012). Regions with such partnerships can also benefit from increased economic development and an improved ability to retain skilled populations (Conway and Giloth, 2014; Harper-Anderson, 2008; Kochan, Finegold, and Osterman, 2012).

Support Micro- or Flexible Credentialing Embedded within Career Pathway Models

Career pathway models are a series of connected education and training strategies and support services that enable individuals to secure industry-relevant certification and obtain employment within an occupational area and subsequently to advance to higher levels of education and employment in that area. These are typically created by employers within a specific industry and education partners. The vision for a career pathways model is to have a workforce development system that aims to be responsive to the needs of employers (a demand-driven education) and accommodates the wide variation in the ways adults sequence their education and careers (Jenkins and Spence, 2006; Lewis, 2008; Stephens, 2009). Because career pathway models are typically devised as illustrations that map varied ways a person can customize his or her education and training to meet a career goal, they can be used
to improve high school students’ awareness about available career opportunities. Career pathway models can also include ways in which students can obtain work experiences along their trajectories as well as which industry-based certifications or credentials they will need along the pathways.

The resulting credentials can be portable across employers and geographies and stackable with other training certifications (Ganzglass, 2014). Flexible credentialing within a career pathway model allows the credentials to be taken to any employer or educational institution, as they are externally accredited and thus universally recognized and accepted. Portable credentials increase geographic and industry mobility for workers, broadening possible career pathways (Center for Occupational Research and Development, 2017). Stackable credentials are industry-accepted certificates that, when combined, can become a higher-level credential like a certificate or associate degree (Austin et al., 2012). The stackable credential model lowers the barriers in time, costs, and training for individuals to enter a skilled job while simultaneously building expertise within a workforce. Moreover, a joint public-private model can more easily and efficiently respond to changing energy and advanced manufacturing workforce needs.

Flexible credential models already exist in the region (see, for example, the ShaleNET), and the TEAM Consortium is working to create career pathways for a select number of advanced manufacturing occupations. However, we suggest that, to improve the sustainability and scalability of these efforts in the region, the API could have engaged more deeply with state and local government and policymakers. For example, Colorado’s Manufacturing Career Pathway Act mandated that workforce stakeholders collaborate to develop stackable credentials to supply the state with manufacturing workers. As another example, starting in the 2014–2015 school year, Louisiana required that all high school students choose either a college preparation pathway with courses that fulfill requirements for entry into Louisiana’s public institutions or a pathway called Jump Start that is focused on career and technical education. The career and technical education pathways in Louisiana are developed and chosen based on labor market demand data for the state and in collaboration with employers (Culbertson et al., 2019). The Ohio Department of Higher Education has also started to develop career pathway models. Such approaches initiated from state government and written into state education policy could connect students throughout the state with skills training based on projected employer demand systemically and could thus prove to be sustainable through time.

Build a Comprehensive Web-Based Career Information Portal

To address labor market issues facing the tri-state region and the lack of awareness about jobs and careers that are family sustaining and readily available in the region, we suggest that ready and available talent needs to be matched to appropriate jobs and careers—a process that can be greatly improved with the appropriate technological infrastructure. Moreover, as discussed in the previous section, real-time job information is critical to the success of building public-private career pathways models. Although web-based job portals abound, most are not geared toward the local job market.

To facilitate matching, we suggest that key stakeholders, such as local industry leaders, collaborate with key intermediaries, such as the TEAM Consortium, Allegheny Conference on Community Development, or local workforce development boards to enhance and improve upon the existing web-based platform that would enable users to link their personal interests and skills to local training opportunities and job openings. Because individuals entering or reentering the labor market generally lack formal career-relevant networks (Calvó-Armengol and Jackson, 2004), such a resource is particularly paramount and would help the unemployed or dislocated workers (such as from coal occupations) retrain in a family-sustaining career in energy or advanced manufacturing.
Future Research

The API made considerable strides in identifying and implementing key investments and in developing measures and other resources for tracking progress toward its goals. However, moving from data to action requires a firm understanding of how the various elements of the system interact, the role of context, and tools available to change the system. To continue to promote the K–12 STEM education and workforce development efforts underway in the region, it is critical to continue research that allows a thoughtful understanding of the issues and challenges confronting the region and to measure progress of the region through time. In the following list, we propose a range of research efforts that could build the system-awareness and analytic capacity to manage the complex network of actors involved in moving the region toward its goals in the energy and manufacturing sectors.

1. **Field a survey to the region’s STEM employers to gain insights on skill needs, on-the-job training provided, and any training or education benefits the employers provide (e.g., educational assistance funds or tuition reimbursement).** This information would provide the region with a deeper understanding of the range of occupational skills needed by various employers and the trainings they offer. This, in turn, could be informative in developing the public-private partnerships and career pathways modeling. This survey could be fielded to those responsible for hiring decisions within a company. For large companies, this could be a chief human resources officer; for smaller companies, this could be the chief executive officer. This survey could first be fielded to the membership lists of oil and gas associations of the advanced manufacturing business members of Catalyst Connection and the STEM employers who are members of Allegheny Conference on Community Development.4

2. **Field surveys to document information or awareness gaps.** In 2014, Campos Research Strategy conducted in-depth interviews with 97 educators and business leaders, surveys of 978 parents and 100 middle and high school students, and seven family home visits in 17 counties in the API region to explore the stakeholders’ awareness of and attitudes toward STEM careers and education. This study could be replicated and expanded to gauge awareness and understanding of career options among talent pools (e.g., middle and high schoolers, college students, young unemployed) and key stakeholders (e.g., parents, guidance counselors, college counselors). This information could then be juxtaposed with career pathway models in the energy and advanced manufacturing industries to determine at which points along the pathways education and industry leaders could improve talent pool and stakeholders’ awareness.

3. **Evaluate the impact of maker spaces, such as the Fabrication Laboratories (“Fab Labs”), a space for students to work with digital additive, subtractive, laser, and slicing technologies.** Although there has been much enthusiasm among teachers, school administrators, and parents about the potential of makerspaces to date, there has been no external large-scale evaluation of their impact. Such an evaluation could explore how this type of hands-on practice outside of a classroom can impact students’ motivations, engagement, or skills related to STEM education and training and how these experiences affect participating teachers’ practices in their classrooms. Fab Labs is a makerspace program that would be a viable candidate for a rigorous evaluation. Currently, there are about 1,000 Fab Labs in 78 countries (Fab Foundation, 2017). And, in the API region, there are sufficient mobile Fab Labs to enable an evaluation. The Greater Pittsburgh region hosts five mobile Fab Labs: three in individual school districts (the Fox Chapel Area School District, the Plum Borough School District, and the Elizabeth Forward School District), two cross-district mobile units in IU1, and one based in CSC that visits
Pittsburgh public schools. These mobile Fab Labs serve elementary school students for periods of time that vary from one to nine weeks at a single school.

4. Document and track the supply of the talent pool (high school leavers, high school graduates, college attendees, recent college graduates and underemployed and unemployed or discouraged workers) available in the region. It is currently difficult for employers to know the types of skills the available talent pool in any region have: Current available data document a school, district, or state’s high school graduation rate, aggregated scores on student assessments (e.g., state standardized assessments, ACT, Advanced Placement, SAT, National Assessment of Educational Progress [NAEP], or international assessments such as the Trends in International Mathematics and Science Study [TIMSS] or Program for International Student Assessment [PISA]), higher education institutions publish the number of graduates with specific degrees, and U.S. Census data provide information on the percentage of people living in a specified geographic areas who have a college degree. Although this information can provide a broad understanding of the supply of talent in a region, it does not provide the detailed information needed to understand the extent to which the region can meet employers’ demands. One way to do this would be to undertake a deep dive on a randomly selected sample of the region’s youth and young adults and follow their education and employment trajectories through time; their specific knowledge, skills, and abilities; and their career inclinations to unpack “supply” and whether and how the supply can meet the region’s labor market’s evolving skills demands.

5. Augment the network analyses undertaken in this study to map all the education and training providers, employers, and intermediaries in the region to document who partners with whom and in what ways. The network analyses conducted in this study documented the relationships among API programs, funders, and partners. However, this provided only a partial picture of the networks in existence in the region. A more detailed network analysis would map which entities are working with each other and in what ways, thus uncovering any gaps or redundancies. Once the network analysis is complete, key ecosystem stakeholders in K–12 STEM education and workforce development could convene to identify action priorities for core components of the region’s ecosystem. This type of workshop would help existing programs to become more effective by mobilizing partners and could also reveal key “choke points” in the system that API partners—or other regional actors—may consider addressing through new projects and programs. This analysis could also improve the region’s agility in standing up programs to address new skill needs as players are aware of each other’s space: STEM employers have rapidly evolving skills needs, and having a regionwide map could increase the region’s agility. A more in-depth network analysis and subsequent ecosystem mapping could also provide information on geographic gaps, allowing the documentation of where available jobs are compared with where talent resides and training institutions exist.

Appendix

This appendix provides details on API-sponsored programs: how each program evolved through the years (Table A), intended beneficiaries (Table B), and the skills-acquisition model each used (Table C).
## Table A
Description of API Programs and Their Evolution (2014–2019)

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<thead>
<tr>
<th>Grantee</th>
<th>Original Program Description</th>
<th>Program Evolution and Rationale</th>
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<tr>
<td><strong>K–12 STEM Education</strong></td>
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<td><strong>CSC</strong></td>
<td>• <strong>Student Energy Summit</strong> is an annual two-day event involving workshops and projects for regional middle and high school students that introduces topics related to energy use and consumption.</td>
<td>• No major changes</td>
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<td></td>
<td>• <strong>Grand Slam Science, On the Road</strong> teaches regional K–8 students physics through baseball. A session at a school includes an assembly show and hands-on experience.</td>
<td>• The CSC completed all Chevron-funded activities in 2017.</td>
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<td></td>
<td>• Chevron funded a stationary <strong>Fab Lab</strong> at CSC and a mobile CSC Fab Lab that travels throughout sites in Southwestern Pennsylvania.</td>
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<td><strong>CMP</strong></td>
<td>• <strong>Explore Making</strong> is a hands-on learning program designed to increase interest in &quot;making&quot; among first-grade students. It includes 32 elementary schools in Fayette, Greene, and Washington Counties of southwestern Pennsylvania and Marshall County of West Virginia.</td>
<td>To improve accessibility to teachers, the program offered additional one-day Professional Development opportunities to schools, in addition to the four-day Maker Boot Camps. In 2018, CMP hosted its <strong>RubeFest</strong> instead of Maker Media’s Maker Faire. RubeFest focused on engineering, construction building, and the concept of cause and effect instead of general making to complement the museum’s exhibit <strong>Rube Goldberg: The Hilarious World of Invention!</strong> CMP partnered with the heirs of Rube Goldberg in the development of this exhibit.</td>
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<td></td>
<td>• CMP facilitated the development of seven new makerspaces across West Virginia through <strong>Building the West Virginia Network</strong>. Support included providing technical assistance, necessary supplies, and honoraria for participation.</td>
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<td></td>
<td>• CMP provides professional development through the <strong>Maker Boot Camp</strong> for the teachers from the 32 Explore Making schools. CMP hosted a <strong>Maker Faire</strong> (licensed by Maker Media) in Pittsburgh to exhibit accomplishments of local makers.</td>
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<td><strong>Education Alliance</strong></td>
<td>The Education Alliance coordinates the <strong>STEM Network Schools</strong> (eight West Virginia schools) in developing their own STEM programs for middle and high school students using CSC STEM Excellence Pathway as a guide. Chevron funds two of the schools.</td>
<td>The STEM Network Schools completed their three-year grant in the 2017–2018 school year. Since 2018, Chevron also began supporting <strong>Blended Learning</strong>, a collaborative effort of seven West Virginia high schools to provide STEM education by blending face-to-face instruction with project-based learning in makerspaces and digital learning through a learning management system for an overall enhanced educational experience. Schools have been able to accrue additional funding sources and volunteers to expand their makerspaces. Schools have also been able to develop partnerships with local businesses for guest speakers, virtual field trips, and support with curriculum development.</td>
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</table>
**Grantee** | **Original Program Description** | **Program Evolution and Rationale**
---|---|---
**IU1** | **Fab Lab** is a digital fabrication laboratory that provides K–12 students and adults a platform for hands-on STEM learning experiences. Chevron funded both a stationary and a mobile Fab Lab at IU1. The program covers areas in Washington, Fayette, and Greene Counties. | • IU1 added two additional stationary labs and a second mobile lab to address the high demand for Fab Labs in the region. IU1 currently has a Fab Lab in each of the three counties served (Washington, Fayette, and Greene).  
• From the early stages of implementation, IU1 program leaders found the Fab Lab to be an effective learning medium for students with therapeutic emotional support needs, learning disabilities, and students with severe handicaps. For this reason, program leaders have developed specialized curriculums for these student populations as well as training for social workers (15 social workers across three stationary labs) to provide support and therapy during Fab Lab time. The new Fab Lab has also been modified to accommodate students with special needs. 

**PLTW** | **PLTW** provides K–12 STEM curricula to elementary, middle, and high schools throughout the United States. Chevron funds PLTW Gateway (grades 6–8) and engineering programs (grades 9–12) in Pennsylvania, Ohio, and West Virginia schools within the API region. | PLTW worked with a total of 30 schools within the API region during the 2018–2019 school year. Initially, API funded the PLTW Gateway and high school engineering programs. In 2019, the API-funded schools also include PLTW Launch for grades K–5. 

**Hybrid K-12 STEM/Workforce Development**

**Catalyst Connection** | • **The Middle School Student Video Contest** matches manufacturers with student teams to create publicly available videos about “what makes manufacturing cool.”  
• **Adventures in Technology** matches middle and high school students with local industry to fund research projects.  
• **The Manufacturing Career Exploration Program** with Girl Scouts involves an advisory committee of women in manufacturing to develop initiatives to attract girls in STEM.  
• **Pathways to Apprenticeship** targets awareness of career and apprenticeship opportunities in manufacturing among teachers, parents, educators, and administrators.  
• Catalyst Connection collaborated with ASSET STEM education to develop a teacher professional development workshop for project-based learning. Chevron funded 100 teachers in the workshop. Catalyst Connection programs cover counties in western Pennsylvania, northwest Pennsylvania, the northern panhandle of West Virginia, and Pittsburgh. | The Middle School Student Video Contest has expanded from a regional competition to a statewide initiative. The programs have increased sponsorship and employer engagement, continue to build strategic partnerships to help fill in STEM education gaps, and have developed pre-apprenticeship programs because of observed gaps between programs in middle school and high school. 

**Central Greene School District** | **The Natural Resources Course** at Central Greene School District is a one-year course for high school students to prepare them for further education or occupations within the natural gas industry, resulting in industry-based certifications. | • There was no change in overall vision or mission.  
• It used to provide course to five local school districts at the Greene County Career and Technology Center, but it is currently unable to because of scheduling challenges across schools. The program is currently only provided to the Central Greene School District students. 

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**TABLE A—CONTINUED**
### Energy Innovation Center
- This is a four-hour safety training program for incumbent workers in oil and gas industry, developed by the Energy Innovation Center in collaboration with health safety and environment professionals and company partners such as Chevron, Shell, EQT Corporation, and more.
- “The goal was to help all companies operating in the basin to further the key energy industry core values of ensuring worker, environment, and community safety and wellbeing while optimizing valuation creation.”
- The course was specifically designed to increase comprehension and retention effectiveness.

### ShaleNET TEAM Consortium
Starting in 2016, Chevron funded four community colleges (Pennsylvania College of Technology, Pierpont Community and Technical College, Stark State College, Westmoreland County Community College) within the API region through ShaleNET, a public-private partnership between employers in the energy sector and community and technical colleges to provide training for careers in the local oil and natural gas industry in Pennsylvania, Ohio, Texas, and West Virginia. API funding went to scholarships, professional development for faculty, purchase of equipment, career planning support, and other aspects of training related to careers in energy, advanced manufacturing, and natural gas. API funding through ShaleNET ended by 2018.

### Pennsylvania College of Technology
- Stronger focus on skills in plastic to match changing industry demands
- Requests for training in the natural gas industry has significantly decreased.

### Westmoreland County Community College
- Stronger focus on skills in additive manufacturing to match changing industry demands
- Data-sharing agreement with the Pennsylvania Department of Labor and Industry’s Center for Workforce Information and Analysis to better track graduating students
- Currently working with employers to establish onboard training opportunities for graduates.

### TEAM Consortium
The TEAM Consortium consists of members from community colleges, manufacturing extension partnerships, and workforce development boards within the API region and is led by the Community College of Beaver County. Currently, the consortium is funded by Benedum, Chevron, and the Appalachian Regional Commission. Although ShaleNET funding largely went to the individual colleges for their specific programs, TEAM Consortium funding focuses on the coordination of activities across community colleges and with the industry. The TEAM Consortium currently consists of 20 community college and university members. The four ShaleNET colleges are also members of the TEAM Consortium.

### Additional Focus
- Additional focus in providing training for oil and gas occupations because those industries have increased demand in Greene and Washington Counties.

### Southwest Training Services
This service supports postsecondary training for dislocated workers from coal-related or manufacturing related lay-offs in Washington, Greene, or Fayette Counties.

### Tables

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<thead>
<tr>
<th>Grantee</th>
<th>Original Program Description</th>
<th>Program Evolution and Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Innovation Center</td>
<td>This is a four-hour safety training program for incumbent workers in oil and gas industry, developed by the Energy Innovation Center in collaboration with health safety and environment professionals and company partners such as Chevron, Shell, EQT Corporation, and more. “The goal was to help all companies operating in the basin to further the key energy industry core values of ensuring worker, environment, and community safety and wellbeing while optimizing valuation creation.” The course was specifically designed to increase comprehension and retention effectiveness.</td>
<td>There were slight changes in course material based on changing industry safety standards. The Energy Innovation Center completed all Chevron-funded activities in 2018.</td>
</tr>
</tbody>
</table>
| ShaleNET TEAM Consortium | Starting in 2016, Chevron funded four community colleges (Pennsylvania College of Technology, Pierpont Community and Technical College, Stark State College, Westmoreland County Community College) within the API region through ShaleNET, a public-private partnership between employers in the energy sector and community and technical colleges to provide training for careers in the local oil and natural gas industry in Pennsylvania, Ohio, Texas, and West Virginia. API funding went to scholarships, professional development for faculty, purchase of equipment, career planning support, and other aspects of training related to careers in energy, advanced manufacturing, and natural gas. API funding through ShaleNET ended by 2018. | Pennsylvania College of Technology
- Stronger focus on skills in plastic to match changing industry demands
- Requests for training in the natural gas industry has significantly decreased. Westmoreland County Community College
- Stronger focus on skills in additive manufacturing to match changing industry demands
- Data-sharing agreement with the Pennsylvania Department of Labor and Industry’s Center for Workforce Information and Analysis to better track graduating students
- Currently working with employers to establish onboard training opportunities for graduates. |
| Southwest Training Services | This service supports postsecondary training for dislocated workers from coal-related or manufacturing related lay-offs in Washington, Greene, or Fayette Counties. | Additional focus in providing training for oil and gas occupations because those industries have increased demand in Greene and Washington Counties. Southwest Training Services completed all Chevron-funded activities in 2018. |

**SOURCE:** Quantitative indicators provided by grantee administrators (August 2016–December 2019) and communication with grantee administrators (2016–2019).
### TABLE B
API Grantees’ Intended Beneficiaries (2014–2019)

<table>
<thead>
<tr>
<th>Grantee</th>
<th>Program</th>
<th>Intended Beneficiaries</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>K–12 STEM Programs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IU1</td>
<td>Fab Lab</td>
<td>K–12 students and educators, adults (through adult education programs), community members, and organizations. Special emphasis on students with therapeutic emotional support needs, learning disabilities, and students with severe handicap</td>
</tr>
<tr>
<td>CMP</td>
<td>Explore Making</td>
<td>First grade students and their teachers</td>
</tr>
<tr>
<td></td>
<td>Maker Boot Camp</td>
<td>Teachers</td>
</tr>
<tr>
<td></td>
<td>Maker Faire</td>
<td>Available to public</td>
</tr>
<tr>
<td></td>
<td>RubeFest</td>
<td>Available to public</td>
</tr>
<tr>
<td>CSC</td>
<td>Student Energy Summit</td>
<td>Middle school and high school students</td>
</tr>
<tr>
<td></td>
<td>Grand Slam Science, On the Road</td>
<td>K–8 students</td>
</tr>
<tr>
<td></td>
<td>Fab Lab</td>
<td>K–12 students</td>
</tr>
<tr>
<td>Education Alliance</td>
<td>STEM Network Schools</td>
<td>Middle school, eventually expanded to high school</td>
</tr>
<tr>
<td></td>
<td>Blended Learning</td>
<td>High school students</td>
</tr>
<tr>
<td>PLTW</td>
<td></td>
<td>K–12 students and educators (as an organization, recently focusing more on girls and women and underserved populations)</td>
</tr>
<tr>
<td><strong>STEM Workforce Development Programs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catalyst Connection</td>
<td>Middle School Student Video Contest</td>
<td>Middle school students</td>
</tr>
<tr>
<td></td>
<td>Adventures in Technology</td>
<td>Middle school and high school students</td>
</tr>
<tr>
<td></td>
<td>Manufacturing Career Exploration Program</td>
<td>Girl Scouts</td>
</tr>
<tr>
<td></td>
<td>Pathways to Apprenticeship</td>
<td>Educators, parents, and administrators</td>
</tr>
<tr>
<td>Central Greene School District</td>
<td>Natural Resources Course</td>
<td>11th- and 12th-grade high school students (with plans to provide classes for adults in the future)</td>
</tr>
<tr>
<td><strong>Workforce Development Programs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Innovation Center</td>
<td>Energy Safety Passport</td>
<td>Incumbent workers in the oil and gas industry</td>
</tr>
<tr>
<td>ShaleNET</td>
<td>PCT</td>
<td>Credit students pursuing technical degrees. Noncredit students, with special focus on unemployed, underemployed, and veteran groups Incumbent workers in natural-gas related industries</td>
</tr>
<tr>
<td></td>
<td>Pierpont College and Technical College</td>
<td>Same as PCT</td>
</tr>
<tr>
<td></td>
<td>Stark State University</td>
<td>Same as PCT</td>
</tr>
<tr>
<td></td>
<td>Westmoreland County Community College</td>
<td>Same as PCT  Career-exploration sessions for local middle and high school students</td>
</tr>
<tr>
<td>Southwest Training Services</td>
<td></td>
<td>Dislocated workers (mostly coal miners) in southwestern Pennsylvania</td>
</tr>
</tbody>
</table>

**SOURCE:** Quantitative indicators provided by grantee administrators (August 2015–December 2019) and interviews with program administrators (2016–2019).
<table>
<thead>
<tr>
<th>Grantee</th>
<th>Program</th>
<th>Skills Acquisition Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>K–12 STEM Programs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IU1</td>
<td>Fab Lab</td>
<td>Hands-on learning experience for students to digitally fabricate own products</td>
</tr>
<tr>
<td>CMP</td>
<td>Explore Making</td>
<td>Hands-on, collaborative learning experience in makerspaces for students to create and make their own crafts and projects to take home</td>
</tr>
<tr>
<td></td>
<td>Maker Boot Camp</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maker Faire</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rube Fest</td>
<td></td>
</tr>
<tr>
<td>CSC</td>
<td>Student Energy Summit</td>
<td>Hands-on learning experience for students to create their own projects (Student Energy Summit)</td>
</tr>
<tr>
<td></td>
<td>Grand Slam Science, On the Road</td>
<td>Hands-on multimedia experience integrating lessons in physics with baseball</td>
</tr>
<tr>
<td></td>
<td>Fab Lab</td>
<td>Hands-on learning experience for students to digitally fabricate own products</td>
</tr>
<tr>
<td>Education Alliance</td>
<td>STEM Network Schools</td>
<td>Specialized STEM curriculum for middle and high schools</td>
</tr>
<tr>
<td></td>
<td>Blended Learning</td>
<td>STEM education through hands-on learning experience in makerspaces and digital instruction</td>
</tr>
<tr>
<td>PLTW</td>
<td></td>
<td>Project-, problem-, and activity-based instructional approaches</td>
</tr>
<tr>
<td><strong>STEM Workforce Development Programs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catalyst Connection</td>
<td>Middle school student video contest</td>
<td>Student-made videos about &quot;what makes manufacturing cool,&quot; partnered with a manufacturing company</td>
</tr>
<tr>
<td></td>
<td>Adventures in Technology</td>
<td>Student research-based projects, partnered with a manufacturing company</td>
</tr>
<tr>
<td></td>
<td>Manufacturing Career Exploration Program</td>
<td>Student research-based projects, partnered with a manufacturing company</td>
</tr>
<tr>
<td></td>
<td>Pathways to Apprenticeship</td>
<td>Project-based learning training for teachers (professional development–related activities) Supporting manufacturing companies in the development of internship and apprenticeship opportunities</td>
</tr>
<tr>
<td>Central Greene School District</td>
<td>Natural Resources Course</td>
<td>Hands-on technical training, courses that cover the scientific background for the industry, commercial driver's license training, and safety training and certificates</td>
</tr>
<tr>
<td><strong>Workforce Development Programs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy Innovation Center</td>
<td>Energy Safety Passport</td>
<td>Hands-on learning of a cross-company safety curriculum</td>
</tr>
<tr>
<td></td>
<td>PCT</td>
<td>Stackable credentialing (with multiple entry and exit points, where individuals may build degrees after obtaining technical certificates or credentials) and career pathways</td>
</tr>
<tr>
<td></td>
<td>Pierpont Community and Technical College</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stark State University</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Westmoreland County Community College</td>
<td></td>
</tr>
<tr>
<td>Southwest Training Services</td>
<td></td>
<td>Work-based learning</td>
</tr>
</tbody>
</table>

**Source:** Quantitative indicators provided by grantee administrators (August 2015–December 2019) and interviews with program administrators (2016–2019).
Notes

1 See the first interim assessment (Gonzalez, Culbertson, Nanda, 2017; Culbertson, Gonzalez, and Nanda, 2017) for detailed discussion about the development of the strategic framework and theories of action.

2 It is important to note that not all program administrators were able to provide the number or description of direct beneficiaries reached for all years we collected data. Thus, there might be gaps in our reporting of program participants’ characteristics. The inconsistency in data limits our ability to fully document the geographic scope and number of beneficiaries touched by the API. For this reason, we do not report the number of beneficiaries by program, and we clearly note in each figure which program provided us with data at which points in time. Furthermore, we asked grantee administrators to report on those who participated in the programs (i.e., direct beneficiaries). Thus, we acknowledge that students, working-age adults, or other stakeholders who were touched by the program indirectly were not reported, producing a possible undercount of beneficiaries. Including the number of indirect beneficiaries would have been difficult for program administrators to estimate and thus produced uncertainties about the quality of the data.

3 A deep literature exists on how network analysis can support ecosystem development and social policy, such as Deleon and Varda (2009), Paarberg and Varda (2009), Retrum, Chapman, and Varda (2013), Varda et al. (2008), and Varda (2010).

4 This includes the Ohio Oil and Gas Association, the Pennsylvania Independent Oil and Gas Association, and the West Virginia Oil and Gas Association. See Bozick et al. (2017) for example survey questions and survey-administration procedures.

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Wolf, Tom, Tri-State Regional Cooperation Agreement, October 13, 2015. As of April 6, 2020: https://9f1252c9-a98b-4df7-ae4e-9591269597a8.filesusr.com/ugd/097d76_aabc4e9818084be1aad83dd7aa782a2e.pdf

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The Appalachia Partnership Initiative

Chevron North America Exploration and Production Appalachian Mountain Business Unit’s Social Investment Team was established to meet several goals in the Pennsylvania, West Virginia, and Ohio region. Goals include strengthening STEM education in middle and high schools and improving pathways for high school graduates and adult learners to careers in the oil and gas industries and in advanced manufacturing. As part of these efforts, in 2014, Chevron’s Social Investment Team launched the API, a partnership of businesses, nonprofit organizations, and education institutions in the region. As of August 2018, API consisted of representatives from Chevron, the Claude Worthington Benedum Foundation, the Grable Foundation, the Allegheny Conference for Community Development, and Catalyst Connections.

The RAND Corporation has served continuously as the independent research and analysis lead for the API. RAND undertook assessments from 2016 through 2020 to track the progress that API-sponsored programs are making in supporting the API’s goals over time.
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About This Report

The RAND Corporation is conducting an assessment of the Appalachia Partnership Initiative’s (API’s) progress toward its vision and goals, with interim assessments conducted from 2016 to 2019. This report is the final assessment and focuses on API’s progress in meeting its goals and vision for K–12 science, technology, engineering, and mathematics (STEM) and workforce development activities as well as community catalyst initiatives from October 2014 through December 2019. This report should interest two audiences: (1) regional education, business, and community leaders concerned with STEM education and the career readiness of workers in the energy and advanced manufacturing sectors; and (2) policy analysts interested in how program evaluation and portfolio analyses can help to advance regional innovation.


This research was sponsored by Chevron Corporation and conducted within two divisions of the RAND Corporation: RAND Education and Labor and RAND Social and Economic Well-Being.

RAND Education and Labor conducts research on early childhood through postsecondary education programs, workforce development, and programs and policies affecting workers, entrepreneurship, and financial literacy and decisionmaking. RAND Social and Economic Well-Being seeks to actively improve the health and social and economic well-being of populations and communities throughout the world. More information about RAND can be found at www.rand.org.

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